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PRESIDENTIAL ADDRESS

THE ORGANIZATION OF THE STUDY OF SYSTEMATIC MYCOLOGY

By S. P. WILTSHIRE, M.A., D.Sc.

In every branch of research, proper organization is essential to satisfactory progress, but especially is this so when the inquiry covers a wide field. Scientists are apt to be so engrossed in the special object of their study that they lose sight of the general subject. They become busied about the bit of work upon which they are immediately engaged and fail to see the problem in its proper perspective. In systematic mycology, for instance, we find individual workers actively occupied with the taxonomy and nomenclature of small isolated groups with comparatively little discussion taking place as to the organization of the mycological forces for the attack on the huge problem as a whole. This afternoon I wish to consider in the broadest outline the problem confronting the systematic mycologist and to suggest some further methods of tackling it.

First of all it is necessary to have a clear conception of the problem itself. According to the recent estimate of my colleagues, Dr Bisby and Dr Ainsworth, there are now 37,500 'good' species and at present about 100,000 names. It must be confessed that such figures are startling in their magnitude. The total number of species of flowering plants originally compiled by Bentham and Hooker in their *British Flowering Plants* was 1315, and every student knows how great was the energy required to master even the common ones. Multiply that nearly thirty times and you then have some vague idea of the size of the task in classifying the fungi.

The problem is, however, much more complicated than with flowering plants, for micro-fungi not only take considerably longer to examine and present much greater difficulties, but the greater part of the classification is still far from being properly established: cultural technique has provided a valuable tool to the taxonomist, but the discoveries made by its means have strained severely the classification based primarily on the study of natural specimens. In some parts of the classification the condition of affairs is chaotic, and everywhere large numbers of putative synonyms add to the difficulties of the situation. The changing International Rules of Botanical Nomenclature are retrospective in their application and were unknown to authors of a large number of species. Consequently many things that might have been done at the time of the original description were left undone. Many species were described without the type collection being preserved, and important items of information regarding structure, colour, habitat, and locality were not recorded. All this has added to the confusion. From this very cursory survey it is evident that the task of reconstruction is gigantic and far beyond the powers of the individual worker.

In contrast, the provision made for research in systematic mycology is meagre. The accurate identification of species is fundamental to the study of pure or applied mycology and yet there is hardly a country where adequate facilities are provided for the study of the subject. In Britain we have only a very small number of workers wholly engaged in identification and other systematic work and, furthermore, few posts are open to systematists, with the result that training facilities in systematic mycology in our universities are correspondingly limited. The sub-committee of this Society, appointed by Council to investigate further how the study of systematic mycology in this country can be developed, has recently been considering these aspects of the problem, and it is to be hoped that success will attend their efforts to find a remedy for the present state of affairs. Of all the countries of the world the United States alone stands out in the number of mycological systematists and in the volume of their achievements.

Appreciating then, the magnitude of the task and the paucity of people to do it, it follows that any means by which labour can be saved must surely be most welcome. The work in hand is so great that, if we want to make reasonable progress in the classification of fungi, we must be content to simplify procedure as much as possible.

In both taxonomy and nomenclature we need to economize our efforts and so order our labour that it yields the maximum results. The actual careful, painstaking work required for the taxonomic study of fungi may not be capable of much benefit from labour-saving methods, but greater concentration on the essential problems could be facilitated by adequate provision for the cataloguing and exchange of specimens and in other helpful ways. Mycologists, or at least some of them, have a horror of anyone except fully trained systematists handling herbarium specimens, but without doubt much of the routine work of the herbarium can be done by trustworthy clerical assistants properly trained for the work. There is a great need in systematic work not only for economy of effort but also for the adequate use of clerical staff.

Most people would imagine that the first requisite of the systematic mycologist would be a complete list of all the names of fungi so far described, in order to limit the field of study. This, however, is not to be had, and so no one can be quite sure that some species of consequence to him is not hidden away in the literature. New species of course are finally listed, notably in Saccardo's *Sylloge*, the last volume of which appeared in 1931 and included species published down to 1920, in Petrak's lists which bring the records to about 1930, and since 1940 in the Supplements to the *Review of Applied Mycology*. No complete list exists, however, although a reliable and satisfactory one, which for the most part alone need be considered, would result in a great saving of time and labour.

The compilation of such a list would be a tremendous undertaking but it might be possible to index all the species listed by Saccardo and Petrak and then fill in the gap between Petrak and 1940. Such an index would only be valuable if Saccardo's *Sylloge* were made available at a reasonable cost, and the plans of our United States friends to republish the whole of the *Sylloge* for about $150 to $200 brings the possibility of a complete list

of species appreciably nearer. Unhappily Saccardo did not list all the binary names published but merely placed the species in what he considered to be their right place in the classification. Consequently the indexes of Saccardo do not constitute a complete list of names, and therefore the work involved in the preparation of such a list is much greater than at first sight it might appear to be. Most of the work could no doubt be undertaken in the first instance by clerical staff, and, if the complete list is considered too big a task, then the species between Saccardo and 1940 alone might be dealt with. Such a compilation would not of course be critical, but it would provide the systematist with the information he needs as to the source of the name.

In all the lists so far published the species are brought together in the first place under the genera, as this is the natural mode of procedure. In the indexes of the *Sylloge*, however, the species are listed under the specific epithet in alphabetical sequence and this method has decided advantages. When Linnaeus introduced binomial nomenclature, he contracted the binomial name from a descriptive sentence in which the generic name was the subject and the specific name was the adjective. As we use the binomials now the specific epithet is the important one and in significance really becomes the subject but remains adjectival in form. For instance, *Macrosporium brassicae* Berk. originally meant the *Macrosporium* called *Brassicae* by Berkeley, now it means the species designated *Brassicae* by Berkeley who classified it in the genus *Macrosporium*. Hence in all cumulative indexes of fungus names it is logical to use the specific epithet as the key word and index under that. This method was adopted in the *Sylloge*, but the authors of the species need to be cited in order to reveal obligate synonyms. It is planned to issue cumulative indexes of the Supplements on these lines every five years.

While there is a specified method of adding to the list of names of species, there is at the moment no formulated method in operation of subtracting from it. The result is that the mycologist has to consider an ever-increasing number of names. There is of course provision made for rejecting the name of a taxonomic group when its application is uncertain or when the characters of the group are described from two or more entirely discordant elements, but the utter rejection of such *nomina dubia* and *nomina confusa* cannot yet be effected. At most an author can state his view that a name is a *nomen dubium* or *nomen confusum*, but still the name exists and has to be considered by subsequent workers, any of whom may disagree with the previously recorded opinion. According to Art. 73 of the Rules a small permanent executive committee is to be established, one of whose functions will be to consider and make recommendations on doubtful or confused names, but so far no fungus names have thus been dealt with. Species that are so inadequately described as to be unrecognizable and of which there are no type collections or material really serve no useful purpose, and the sooner their names are entirely eliminated the better. If there were a list of names proposed for ultimate deletion if no one spoke for them, it would provide the basis on which some future congress might act. The result would be the elimination of a number of doubtful species and a

corresponding clarification of the systematic situation. As a consequence of this preliminary weeding out we should still be left with a large number of synonyms either obligate or facultative; the former would become evident from the index of specific names if arranged according to the specific epithet; the latter would be more difficult to trace, though it is even more important for this to be done. The value to be attached to facultative synonyms depends upon the weight of opinion behind them and, consequently, the ordered documentation of this opinion is a matter of some interest. The days of authority are past. It is not enough for an author to state that one name is a synonym of another; he must tell us why he says so, whether it is based on the examination of an authentic specimen, from the description, or whether he is just quoting someone else. So long as mycologists merely copy one another's synonymy, the number of acceptances does not make it any more probable, but opinions based on the critical examination of specimens and data are worthy of record, though it must always be remembered that the opinion of even a competent taxonomist may be valueless unless he knows all the species in a genus. The listing of all newly established facultative synonyms, with references to published relevant critical opinions, would not be an impossible task, especially if mycologists themselves saw to it that published critical opinions were noted in such a list. The older facultative synonyms are gradually incorporated in the literature and there is not the same need to list them.

The acceptance of the type method in taxonomy by the International Botanical Congress at Cambridge in 1930 gave a new orientation to systematic study. The diagnosis no longer determines absolutely the species unless it conforms with the original or type material from which it was drawn up. Consequently it is of vital importance to know whether type collections exist and where they are to be found. The lack of information of this sort causes hours of labour to be wasted as well as great delay in the progress of research. For instance, the identity of the genus *Stemphylium* based on *S. botryosum* was misconstrued for years, and when its true interpretation was suspected it was not until the type collection was discovered that it was possible to establish indisputably what must otherwise have remained only a conjecture. For many years no one suspected the existence of such a collection, which lay undisturbed until Wallroth's herbarium was unearthed at Strasbourg. This is no isolated case, as, owing to mycology being regarded as a minor subdivision of botany, some of the most famous collections were stored in parcels as received and not incorporated in the general collections. This happened with Montagne's herbarium in Paris, where it was still tied up in the original packages as late as 1929, though it has since been distributed. The herbarium of the great Persoon was similarly stored in the basement at the Rijks Herbarium of Leyden until very recent years, and an equally notable example is that of Corda's herbarium, which everyone had taken for granted to have been lost at sea when Corda himself was drowned in the West Indies in 1849, whereas it was found by Dr Albert Pilát safe at Prague in the herbarium of the National Museum just before the war. Had the existence of these herbaria been generally known, how many hours of work would have been

saved and how much more progress would have been made! Since the last International Botanical Congress the Committee on Nomenclature of the Botanical Society of America undertook to gather data on the location of type specimens. A preliminary list in mimeographed form of the herbaria of notable mycologists and the places where they are preserved was circulated some years ago but it is far from complete, and it is to be hoped that an amplified list will be forthcoming. Even so, we would like to have more than that: if the type method is to function properly there must be some way of finding out whether type material exists or not, either by the issue of catalogues of type collections in the various herbaria or by some method of inquiry.

The adoption of the type method was, I believe, the logical outcome of taxonomic practice, but there is no doubt it has revolutionized the whole method of procedure. In making so big a change it was to be expected that various difficulties would arise and some of these are the result of the lack of precision in the meaning to be attached to the term 'type specimen'. According to the International Rules the type of an epithet is usually a specimen or preparation but may be a description or figure. In general botany and entomology the actual specimen studied by the author is frequently taken as the type, and is then termed the holotype, but, as my colleague Mr Mason has explained to the Nomenclature Committee of this Society, this does not hold in mycology, where the author of a new species bases his description usually on a number of specimens or a collection. For example, *Coniothyrium Arecae* Padwick & Mehr was described from a collection of leaves bearing the fungus made by the senior author at Titabar, Assam, and designated by the authors as the type collection (G. Watts Padwick, No. 436). Now each of these leaves has an equal claim to be regarded as type material (the syntypes of the entomologist). That is the interpretation normally put upon the term 'type collection'. If the authors had specified one particular slide or leaf as the type, then that would of course settle the matter, but an author usually studies, and ought to study, a great many specimens before describing a new species, and it is rare for him to designate one slide or leaf as the type. Furthermore, even one particular specimen studied by the author may be divided into half a dozen or more specimens for storing in the herbarium. A 'specimen', according to Daydon Jackson, is 'a plant or portion of plant prepared for botanic study'; according to the *Concise Oxford Dictionary* 'an individual or part of an individual taken as an example of a class or whole'. But in mycology a leaf may bear, say, half a dozen individual colonies of a fungus upon it, and normally the term 'specimen' would apply to the leaf as a whole and not to the individual colony of the fungus it carries. The fact is, the term 'specimen' is ambiguous. Normally the material designated by the author as the type collection is taken by him as an example of the species he describes. I suggest therefore that Art. 18 of the International Rules, which states that 'The type of the name of a species or group of lower rank is usually a specimen or preparation', should be extended to read 'except that the type of an epithet among micro-fungi is almost universally a collection'. It follows that all the material of a type collection has equal value wherever it may be

deposited. For instance, Curtis sent numerous collections from America to Berkeley, who described many as new under Curtis's collection numbers. It has frequently been stated that the type specimens of these American species are in Britain and not in America, but that is not so. Material from the cited collection which satisfies the diagnosis is equally type material whether it is now in England or America. But we can take a case closer home. Berkeley and Broome jointly published a large number of British species, and Berkeley's herbarium has gone to the Royal Botanic Gardens, Kew, and Broome's to the herbarium of the British Museum (Natural History). Again, type material of these species can usually be found in both places and one is not more valuable than the other. In the same way in South Africa it is taken for granted that the part of a MacOwan or Medley Wood collection retained in that country is as much type material as that sent to Kew and used by Cooke as the basis for a new species, and I really do not see how anyone can object to this. The parts of the fungus used by Cooke for his examination were not preserved. For purposes of comparison the right species has to be taken from the original material and identified whether that material be preserved at Pretoria or Kew.

The appreciation of this will simplify taxonomic procedure very considerably, for no longer will it be necessary to hunt the world over for the specimen the author actually studied, or rather, what is left of it; any portion of the type collection will serve for purposes of comparison provided it carries a fungus recognized as that originally described. The advantages are obvious, and if a type collection is found ultimately to comprise two or more species, then provision is made in the Rules for anyone who desires to split them to do so, provided the original name is kept for one of the species.

For many species, however, no type collection is in existence, and the question arises, what is to be done in these circumstances? While no data are available, the proportion of species without type material may very well be as large as a third or a half. In some groups the proportion may be even larger, as none of the older Agarics appear to have type specimens. Fries, for example, assumed that with his descriptions specimens were unnecessary, especially as he always noted the locality of the collection. Consequently he kept no specimens at all, though at Upsala you can still see, I believe, the sycamore tree from which he first described *Rhytisma acerinum*. It follows that for many species the description and perhaps figures must serve as the type. Even so, the foundation of numerous species must be very insecure, and for the establishment of any system of classification lectotypes will have to be chosen and accepted as representing the species concerned. Ultimately, every species that it is decided to recognize should, strictly speaking, be represented by a type or lectotype, or at least a lectotype will have to be chosen if the identity of the species is questioned. At the moment, however, it is not at all clear what a mycologist should do when no type material can be found. The last International Botanical Congress agreed that Appendix I to the International Rules of Botanical Nomenclature should be devoted to Regulations for the governing of types. Drafts of these regulations were to be submitted to the Congress that was

to have been held at Stockholm in 1940. Until the regulations for determining types and for selecting lectotypes when no type material exists are settled, systematists will be working under a great handicap and progress in research will be correspondingly retarded.

Type collections are so valuable that a recognized technique for their examination should be worked out. Up till now there is no thoroughly satisfactory method of preserving indefinitely slides made from type specimens. Shear's double cover-slip method lasts for a good many years but bubbles are apt to accumulate in the preparation ultimately, due probably to the use of Canada balsam as a seal. A method is required that will give uniformly good results so that no type material is wasted.

The continual accumulation of newly described species makes it necessary that nothing should be added to the list without proper data being supplied. Not every author of a new species appreciates the responsibility he shoulders. Under existing conditions anyone has a right to propose a new species. For the most part this liberty is exercised with restraint, but not always, and there is no doubt even now species are being described that lack essential data. Everyone will of course agree that it is the duty of an author to provide the fullest information about the species that he can obtain, but with the best will in the world it is very easy to overlook some point or other that may prove of importance later on. Moreover, the specific criteria are often ill-defined when the description is made. For instance, nearly 1000 species of *Cercospora* were described before the basal scar of the conidium was recognized as supplying a diagnostic character. Consequently it is to be expected that descriptions will need to be revised again and again as taxonomy progresses. Nevertheless, in spite of this continual change in criteria, the question remains whether it is not possible to devise some means of ensuring that the description of a new species shall be as accurate and complete as possible. I believe something might be done in this direction. Would it not be feasible, for instance, to publish minimum specifications for species of the better understood groups or genera? I believe such specifications would provide a most useful framework for the diagnosis and facilitate the compilation of the essential data. It need not hamper the author, for he would of course be able to add any further details he desired. Individual workers, no doubt, have such specifications for the groups they are studying, but it would be advantageous if these were made public and everyone were to work to some plan. At present the rule is that any diagnosis (in Latin) validates the publication of a name.

An important adjunct to any description, which is sometimes omitted entirely, is the provision of ample and accurate figures. Had it been a practice from the start to supply proper illustrations with the description of a species, the detection of spurious new species would have been facilitated and probably a number would never have been published. A satisfactory illustration conveys more to the mind at a glance than a lengthy description in words, and in identification work it is a very great help, as every mycologist knows, to find good pictures of the significant species. It is recommended in the International Rules (Rec. XXIV) that figures should ac-

company descriptions of new species, but I believe that if the study of systematic mycology is to be properly organized it is indispensable that adequate figures should be provided. If the author of a species cannot draw, then someone should do the illustrations for him. The time to take trouble about a species is when the species is being described; it may save much labour later on. A real economy of effort is possible I believe in this direction. The question of expense is of course important, and particularly so when coloured plates are required. Even line drawings without colour are very useful, especially when coupled with precise written descriptions of the colour by using some simplification of Ridgway's nomenclature such as that recently proposed by my colleague Major H. A. Dade. In any event, however costly figures may be, if the publication of a new species is warranted then I believe that the expense of adequate illustrations is justified. One further point about figures concerns their magnification. The Rules recommend that authors should indicate clearly and precisely the scale of the figures they publish, but if figures of allied species are to be compared, then it would be preferable for the magnification employed to be the same, for critical points in size cannot be appreciated unless this is done. Would it not be a good thing, therefore, to standardize magnifications for certain groups and structures? For instance, the perithecia of Erysiphaceae might be standardized at $\times 250$, the asci at $\times 500$, and the ascospores at $\times 1000$. I realize that difficulties exist where variation in size is very great, but even so a standard magnification would bring out such variation and not camouflage it, and it would always be possible if the standard magnification were too low to add supplementary figures at any magnification the author desired. Standardized magnifications would not of course affect the scale at which authors draw but only the scale on which their figures are reproduced. Just how far it will be possible to go remains to be seen, but if authors and editors are able and willing to assist in this matter I believe useful results would accrue.

The value of good figures as an aid to identification has induced phanerogamists to publish the well-known *Index Londinensis* in which illustrations of flowering plants are catalogued. In fungi satisfactory illustrations are often wanting, but I believe the listing of good figures would well repay the labour involved. Volumes XIX and XX of Saccardo's *Sylloge* are devoted to an index of figures, but as these volumes appeared in 1910 and 1911 there is much to do to bring them up to date. Some of the older figures published, especially of the macrofungi, are comparatively rare and inaccessible. The republication of these by modern methods, such as the Replika Process,* may possibly be feasible in the future.

In nearly all diagnoses of fungi, size of spores constitutes an important character and in this regard there are two matters that seem to me to be worthy of consideration. First, the degree of accuracy of measurement that can be obtained by ordinary means does not exceed $0{\cdot}5\,\mu$, or at most $0{\cdot}1\,\mu$. Sometimes figures to three places of decimals are given for spore measurements, especially in spore averages, and my colleague Major Dade has repeatedly called my attention to cases of this sort where all figures beyond

* Of Percy Lund, Humphries and Co., Ltd.

the first place of decimals at most are without significance. Authors seem to think that, when measurements are made correct to 1 μ, the average of a number of such measurements can be computed correctly to 0·1 μ or even less, but this is not so. Secondly, the number of spores to be measured in order to obtain a true measure of the spore size is by no means generally agreed upon. Many of the measurements incorporated into the early volumes of Saccardo's *Sylloge* were taken from a single measurement only, many present-day mycologists make ten or twenty measurements, taking care to include the maximum and the minimum, and others again measure 200 or more and draw neat frequency histograms. Harter in 1941 has shown that conidial measurements of *Fusarium* made by different investigators from the same microscopic preparations of the same species may vary considerably when groups of fifty spores are counted, but that 150–200 measurements may be taken to represent a fairly reliable sample of a population provided the spore suspensions are carefully prepared and mounted. It is possible that in certain groups fine distinctions in spore measurements may be brought out by measuring 200 spores, but in view of the great plasticity of fungi it is very doubtful whether such methods are generally applicable. Variation itself may be a direct result of environmental conditions. For instance, Mr Petch once found that *Cercospora nicotianae* on tobacco leaves kept in a vasculum overnight doubled the length of its spores! The most practical procedure in measuring spores seems to me to be to survey the preparations, judge of the mean dimensions roughly, and to give these with an indication of the extreme range, the number of spores measured being about twenty. An accepted mode of procedure is, however, required in order that a standard method may be adopted by mycologists for this very important taxonomic criterion.

Date of publication is a matter of importance for any species, for the whole system of nomenclature is based upon the principle of priority. A difference of less than a month in the date of publication of two identical specific names is by no means so rare as might be imagined. Now there is no doubt that misdating of periodicals does occur, even sometimes when an alleged date of publication is printed on the cover. It is a very difficult thing indeed to ensure that the printed date of issue of a journal shall be strictly accurate, for many things can happen to prevent punctual delivery by the printer. So great are the possibilities of this, especially under war conditions, that unless an editor is prepared to allow a very wide margin to the printer it is better not to print the precise date of publication on a journal but to quote it in a subsequent issue. Under the Rules, in the absence of proof to the contrary, the printed date must be regarded as correct, but more care is needed in this matter, for otherwise I can well imagine lengthy discussions about dates of species in the years to come.

One of the minor subjects of dispute in nomenclature at the present time is the recommendation to utilize capitals for certain specific names. All sorts of excuses are put forward in the defence of the use of capitals. It has been claimed, for instance, that it is illiterate to write '*de Baryanum*' in one word with a small *b*. The only value of capitals that I can discover is that occasionally it is useful to know whether the author of a species is using

the specific name as a noun in opposition or not. But this benefit is very dearly purchased at the expense of much labour in other directions. As the editor of an abstracting journal of cosmopolitan material it is impracticable for me to spend hours finding out whether specific names of fungi and their hosts should have a capital or small letter. Necessity has compelled us to dispense with the capital, and in economic work generally the same has been experienced. The foresters are outspoken for this harmless but very necessary reform, and a sign of the times is the publication by the Royal Botanic Gardens, Kew, the home of *Index Kewensis*, of a list of economic plants by H. C. Sampson in which no capitals are given to specific epithets. The last of my colleagues to support the capitalization of specific names recently spent some four hours trying to decide on the names of about half a dozen hosts and ultimately found that in some instances it was impossible to determine whether a large or small letter was right; so he came to the conclusion, wisely I believe, that the task was just a waste of time. I hope that others will come to the same opinion.

The documentation of systematic mycology is a subject that receives less attention than it deserves. There is no abstracting journal in the world which covers the subject fully. For many sciences an efficient abstracting service is regarded as a vital necessity, but the high cost of running such a service makes it difficult to see how it can be provided for other than pathogens of economic importance. Moreover, the value of such a service to the systematist would not be so great as to the plant pathologist, for the mycologist normally requires full details given in the original papers. The great need, as I see it, is for adequate indexing of the literature rather than for more abstracting. Part of the indexing is already covered by the listing of new species and new combinations, and a further part would be covered by the listing of facultative synonyms, and by the listing of figures. More is required, however, and if the subject is to develop rapidly adequate documentation facilities seem most desirable. In this connexion I cannot resist referring to the Universal Decimal Classification which provides a standard system of indexing though it is to be regretted that Engler and Prantl's system was adopted as its basis. The classification of fungi is so fluid that it seems premature to adopt any detailed system at present, but the idea behind the Universal Decimal Classification is good and with modification might perhaps play a part in the study of mycology, as it has already done with such conspicuous success in certain other sciences.

The presentation of results of mycological research is another subject that is worthy of thought. The basic unit of systematic mycology is the species, and in my judgement the unit of publication should be the species also. The writing of monographs on particular genera is of course most valuable work, and every systematist wishes we had more of them. As soon as a monograph is published, however, it tends to become out of date, for new species are constantly being described, and this means that monographs have to be rewritten or supplemented at intervals. Would it not be an advantage if the method of publication could be so arranged that new matter could be incorporated into the monograph from time to time without the necessity of reprinting the whole? The solution seems to me to be the

adoption of the loose-leaf mechanism of binding and the publication of loose sheets each devoted to a single species. New species added could be interpolated with ease and the information about each genus kept up to date. Furthermore, the writing of a monograph is usually a prodigious undertaking, and in many instances, I believe, much valuable information is lost to systematic mycology simply because of the difficulty of recording it. The preparation of a sheet dealing with a single species, from material which an author has available for study in quantity, is a comparatively easy task, and yet the contribution to the study of the genus would be very real. Comparative studies of all the species in a genus would have to be made from time to time, but species already satisfactorily described would not have to be dealt with again and the effort could be concentrated on those species that needed it. In phanerogamic floras, the loose-leaf system has already been adopted by Degener for his *New Illustrated Flora of the Hawaiian Islands*, and I hope the method will spread to mycology. Furthermore, in compiling floras of different territories, it would be quite simple to select sheets for species described for those territories and at the same time to build up complete records of all the species described. The new method would not conflict with the publication of periodicals, for critical revision work would have to be recorded in full in these and the results only incorporated into the flora. The publication of such sheets may well be the despair of librarians unless each individual sheet is treated as a separate publication. Each should have a title, number, date, and the name and address of the author as well as that of the publisher. For the convenience of librarians the sheets could be filed numerically as issued, with cumulative fungus and host indexes issued at intervals, whilst the student could arrange his sheets according to the systematic position. The scheme would harness all workers in fungi in the task of recording systematic knowledge of fungi; plant pathologists would be interested in those attacking economic plants; the timber mycologist in Polypores and other timber-rotting fungi; and the medical mycologist in those associated with diseases of man. It would be necessary for sheets to be standardized in form, size, and general arrangement as well as in the method of presenting the information. The printing and organization would probably have to be localized in a few centres for editorial purposes and to secure some uniform standard for the work as well as to facilitate distribution, but mycologists the world over could co-operate in the enterprise. Such a plan would afford a stimulus to the study of fungi and should produce good results.

One other matter and then I have nearly done, namely, the exchange of specimens. However good the printed description of a fungus may be, it will never supersede the fungus itself. Specimens are essential and the more the better. For some time past exchange clubs have operated in this country for phanerogams, but very little has been done regarding fungi. If the study of systematic mycology is to advance, as we all hope it will, then anything done to assist in the exchange of specimens will be of value. It would, for instance, be a great help for students to be able to get hold of their own named specimens and would assist our herbaria in filling lacunae in their collections. It would help the plant pathologist in identifying his pathogens.

The preparation of exchange material is an essential part of the work of the laboratory or herbarium staff, and provision for this work surely ought to be made. There are of course dangers in the transference of plant-pathogenic fungi from infected to non-infected regions, even in the form of specimens, and adequate safeguards and restrictions will have to be imposed. A committee appointed by the second Imperial Mycological Conference, 1929, recommended that in the event of a dried specimen of a plant carrying a dangerous disease being transmitted from one country to another where that plant or susceptible plants are under cultivation but are free from disease, it should be poisoned before despatch (e.g. by painting it with, or dipping it into, a 1 % solution of mercuric chloride in strong alcohol) and be marked 'poisoned'. Fresh specimens so transmitted, it was recommended, should be burnt without delay.

Reviewing then the present position of systematic mycology as a whole, what is the feature that comes out so conspicuously again and again? Why, its international character. The problem is an international one, and its solution requires attack on international lines. The mycologist working alone is confronted with a task entirely beyond his individual capacity, and in almost every direction international collaboration is necessary for rapid progress. However great the energy of an individual may be, he can only hope to cover a limited field and make a slight impression upon the mass of work to be done. International co-operation in the study of the subject with some sort of co-ordination of the work may be expected in time to result in a working force adequate to deal with the gigantic problem. The subject is indeed a big one, and I do not propose doing more than to indicate the need for considering it on the broadest lines. The critical study of genera and species must remain the basis of all progress in classification, but the taxonomist needs to have all means at his disposal for reducing his work to a minimum. Taking the various points I have discussed this afternoon, would it not be delightful for mycologists to have, say, a complete list of all species described, reduced to minimum size by the continual elimination of doubtful species; lists of obligate and of recently established facultative synonyms, with reference to critical opinions; a more or less complete catalogue of the classical mycological herbaria showing their location, if not a catalogue of type collections; a clear procedure to follow in the absence of types; a well-indexed literature capable of being kept up to date; and last, but not least, a loose-leaf flora in which may be recorded the salient features of known species?

Progress in such a difficult study as systematic mycology cannot be expected without sustained, arduous effort, but I believe the labour required could be lightened by keeping well to the fore the necessity of planning mycological study on the broadest basis and by providing adequate facilities for tackling the work on the requisite scale.

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SOME METHODS FOR THE STUDY OF MOULDS

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Part I. Preparation of museum specimens of moulds by cultures made on paper or cellophane disks

One of us (A. F.) found that if disks of paper or cellophane were placed on the surface of a solid culture medium the elements necessary for growth diffused through the disk, so that growth was obtained of bacteria planted on the surface of the disk. Cultures of most of the pathogenic bacteria do not show up well by this procedure, but the bacteria which form brightly coloured colonies, such as *B. prodigiosus*, *B. violaceus*, *Staphylococcus aureus*, or yellow sarcina, can be beautifully demonstrated if grown on white paper laid on the surface of agar, blood agar, or other suitable solid medium.

When growth had occurred the disk was removed from the culture medium carrying with it the culture and could then be sterilized in formalin vapour, mounted on a card, and preserved as a permanent record.

Later, this method was applied to moulds, and it was found that beautiful colonies could be obtained and preserved in this way.

Technique

Disks of paper or cellophane are cut out a little smaller than the culture plates so that they will fit in easily. It might at first be thought that filter paper would be the most suitable as the nutrient material would most easily pass through. While this latter supposition may be true, filter paper is not always the best material as the mould colony may grow through it and firmly fix itself to the underlying agar medium, so that it is impossible to remove the colony without tearing the paper. It was found that good colonies could be obtained by using disks of good quality hard notepaper (not heavily glazed) and that even old cultures could easily be removed from the underlying medium on the paper disk. Many mould colonies show up better on a black surface, and excellent results can be obtained with disks of a cheap paper, dull black on one side and white on the other, which has been used to make black backgrounds in laboratory bench demonstrations. For special purposes, paper disks of any colour may be used. On these paper disks the surface appearance of the colonies is admirably shown.

Cellophane disks may likewise be used. The nutrient material readily diffuses through the cellophane, and well-developed colonies can be obtained. As the cellophane is quite transparent the reverse is in no way concealed.

The disks, after being cut, may be placed in a Petri dish and sterilized in the autoclave. There is no difficulty with the paper disks, but the cello-

phane becomes wrinkled if it is not kept moist, so in sterilizing it is wise to interleave the cellophane with moist blotting paper in the Petri dish.

The sterile disk is then placed on the culture medium. The paper disks may curl up, but if they are left for a short time they can easily be flattened down on the surface.

Mould spores are planted with a wire on the centre of the disk and the plate is allowed to stand on the bench or incubated at a suitable temperature. When the colony has reached the desired size the disk can be removed and placed in another Petri dish with some 10 % formalin, or a piece of filter paper soaked in formalin can be placed in the lid of the plate which is left inserted for a few days during which the culture is exposed to concentrated formalin vapour.

These disk cultures can be mounted on a card like a photograph, and protected with any suitable glass covering, or they may be mounted on a convenient piece of glass and similarly covered.

A very suitable way of mounting the paper or cellophane disks is to stick them on to a flat spectacle lens blank (a circular glass disk about 2 in. in diameter). Then a curved spectacle lens blank (like a watch glass) is inverted over the disk, and the whole is placed in an incubator or a cupboard, out of the way, until it is completely dry. Then the two pieces of glass are stuck together by any convenient means, but probably the simplest is by a narrow strip of surgical strapping running round the circumference. If, however, the disk is too large for this mount it may be stuck on a lantern-slide cover-glass and protected with any suitable glass cover.

Sometimes when the colonies are dried they crack and the specimen is spoilt. This can be obviated by filling the space between the flat and concave glasses with a mixture of equal parts of glycerin and 4 % agar. This can be filled in a temperature of 50 or 60° C., and it sets into a stiff, transparent gel. These agar-filled cells have to be hermetically sealed to prevent drying. The agar filling sometimes seems to improve the appearance of the colony, and the colour is well preserved.

Cellophane disks have an additional advantage in that with some moulds the colony floats off when the disk is placed in water. The technique used has been to place the cellophane disk with the mould colony on the surface of a 10 % formalin solution half filling a Petri dish, and to replace the lid. After a time the cellophane falls to the bottom of the dish leaving the naked mould colony swimming on the surface of the formalin. When the colony is fixed a glass mount is introduced into the dish and the colony is removed on its surface, when it is treated as the paper disk by mounting dry or in glycerin agar. Colonies on paper disks mounted dry as described above have retained their characteristic appearance for some seven years.

Various thicknesses of cellophane have been used. This substance is marketed in thicknesses of 300, 400, 600 and 1200 (plain transparent), having a relative thickness of 1, $1\frac{1}{3}$, 2 and 4. Good growth of the various moulds tried has been obtained on the 300, 400 and 600 thicknesses, but growth of *Penicillia* was less profuse on 1200 thickness. The thinnest is apt to become wrinkled with the mould growth and difficult to mount, but no. 600 has usually been found to be very suitable.

Part II. Cellophane culture as a method of examining germination of mould spores and of studying older cultures of moulds

It has already been shown that typical mould colonies can be obtained by planting spores on the surface of cellophane placed on a solid culture medium. As cellophane is a perfectly transparent substance it appeared that it would be an admirable substance to use for observations on the germination of spores, and for examination of mould cultures with the minimum of disturbance. For this purpose small cellophane squares or disks were placed on a solid culture medium, and then mould spores were planted on the surface of the cellophane. When growth had taken place for the requisite time a cellophane slip was removed and examined.

Methods of examination

(*a*) *Negative staining.* The simplest method is to place on a microscope slide a small drop of 10 % nigrosin (containing formalin as a preservative), and to invert the cellophane on it so that the germinated spores are on the lower surface in contact with the nigrosin. The slide is inverted on a piece of filter paper and sufficient pressure is applied to reduce the nigrosin film to the right thickness. For immediate examination the cellophane acts as a cover-slip, and the germinated spores stand out as clear objects on a dark field.

An alternative method is to place the cellophane slip with the germinated spores uppermost on a microscope slide. A small drop of nigrosin is now placed on the surface and a cover-slip is applied. If the weight of the cover-slip is not sufficient to spread out the nigrosin into a sufficiently thin film gentle pressure must be applied to the cover-slip. This method has the advantage that drying is much slower so that there is ample time for observation and photography.

The nigrosin solution. When 10 % nigrosin solution in water is used it will be seen with some moulds that the ends of the young hyphae and their branches burst, extruding a finely granular material. This effect can readily be watched under a $\frac{1}{2}$ or $\frac{2}{3}$ in. objective, and it can be avoided by adding up to 5 % of salt to the nigrosin solution.

Permanent negatively stained preparations can be made by holding the small cellophane slip for a minute in the neck of a bottle containing 2 % osmic acid, and then allowing it to dry. It is then placed on a slide (film side up), a small drop of 10 % nigrosin is put on one side, and while the cellophane is prevented from slipping by forceps or otherwise, this nigrosin is spread with another slide over the surface of the cellophane and allowed to dry. The slip is then mounted in Canada balsam.

(*b*) *Positive staining.* (i) *Recently germinated spores.* These can be stained with any ordinary basic dye, but most of them have the disadvantage that they stain the cellophane. The best results on cellophane strips have been obtained with lactophenol-picric-acid-nigrosin.

The simplest method is to put a loopful of lactophenol on a slide and to place the cellophane strip (film side up) on this so that there are no air bubbles between the cellophane and the slide. A drop of lactophenol-picro-nigrosin is now put on the surface of the cellophane and a cover-slip is immediately applied. This can be ringed with Noyer's cement or other substance. With some moulds, such as *Fusarium*, staining is almost instantaneous, but with others, such as *Mucor*, it is much slower. Specimens prepared in this way show up well after some months.

More elegant specimens can be obtained as follows: the cellophane strip is placed face down on the surface of the lactophenol-picro-nigrosin in a watch glass. After two minutes the slip is removed with a pair of forceps and the stain is drained off on to a piece of filter paper. It is then placed on a clean slide, covered with a drop of lactophenol, and mounted.

Alternatively after the slip has been stained it is placed in a watch glass of water until the excess of stain has been removed. It is then carried through two changes of alcohol, and mounted in Gurr's mounting fluid.

These staining methods show up the germinated spores and young hyphae as black objects. The septa are clearly indicated. The cellophane is practically unstained.

Fusarium spores were planted on cellophane strips on agar. After five and a half hours at room temperature they were commencing to germinate and short germ tubes could be seen usually (but not always) coming first from one or both ends of the spore. This happened at the end of the day, and to prevent further development during the night the culture was placed in the refrigerator at about 3° C. When examined next morning it was found that the germ tubes had become swollen, and it appeared as if the organism had commenced to form chlamydospores. After a further two hours at room temperature young hyphae grew out from these swellings and development seemed to proceed normally.

(ii) *Older cultures with fruiting bodies.* With these older cultures the best results have been obtained with lactophenol-picro-nigrosin staining. The disk is removed from the culture plate, wetted with alcohol, and inverted on a drop or two of the stain in a watch glass. After two minutes the disk is removed, the excess of stain is removed with filter paper, the specimen is washed with a drop or two of lactophenol, and mounted in the same substance. The cover-slip may be lightly pressed down.

The fruiting heads are deeply stained and can be seen beautifully immediately under the cover-slip, while by focusing down the more lightly stained mycelium is brought into view.

Older colonies on cellophane strips can be removed and stained with lactophenol-picro-nigrosin, washed with lactophenol, placed in a shallow cell filled with lactophenol, and covered with a cover-slip. In this way the weight of the cover-slip is taken off the colony and the fruiting heads can be seen well above the mycelium.

Part III. Notes on some methods of mounting moulds

For the routine examination and identification of moulds it is usually necessary to prepare flat mounts of mature fruiting organs, taken either from naturally occurring specimens or from suitable cultures. The method of mounting should be such as will give a presentable slide with the minimum of manipulation, since the majority of moulds are very fragile and have to be handled very carefully if structures are to be preserved whole.

A few species can be mounted satisfactorily in plain water but, with most moulds, hyphae are wetted only very slowly and imperfectly and the resulting preparation is spoiled by the presence of numerous air bubbles. Water is too volatile to serve for more than a rapid examination and has the further disadvantage that it often causes marked swelling. Alcohol wets well but is more volatile than water. Glycerol is non-volatile but does not wet satisfactorily if pure, and in aqueous solution is not a preservative.

Lactophenol

The most satisfactory medium for general use, and one which is widely used at the present time, is lactophenol (Amann, 1896). A number of modifications of the original formula have been published but it is doubtful whether any of these has advantages over the original recipe. Amann's formula is:

Phenol (pure crystals)... ...	10 g.
Lactic acid (syrup, sp.gr. 1·21)	10 g.
Glycerol (pure)	20 g.
Distilled water	10 g.

This fluid wets most species fairly readily, it rarely causes either swelling or shrinkage, it is non-volatile and is sufficiently viscous to allow of the use of an 0·1 objective without displacement of the cover-glass.

Although shrinkage is rare it has been found to occur with a few dematiaceous fungi, notably a few species of *Helminthosporium*. The hyphae are apparently unaffected but the spores partially collapse and, for purposes of measurement, are best mounted in water.

Another type of change occurs with some highly pigmented fungi, the colouring matter, which is often present as a sodium, potassium or magnesium salt, being attacked by the acidic mounting medium with liberation of the free acid, which crystallizes out on the slide. The bright red pigment of certain species of *Fusarium*, notably *F. culmorum*, is thus dissolved from the hyphae and redeposited as crudely crystalline yellow aggregates. *Aspergillus ruber* secretes a red pigment as small irregular granules encrusting the hyphae. This is rapidly dissolved by lactophenol and redeposited as long fine needles of the almost colourless free acid.

Another phenomenon, observed with a number of *Penicillia* and *Aspergilli*, is the gradual appearance of numerous oily drops, probably formed by solution of fat from the mycelium and its redisposition around the specimen. It is seldom that any of these changes interferes with observation of structure but such slides are useless for photography.

Stains for use with lactophenol

The refractive index of lactophenol, approximately 1·45, is very close to that of the hyphae and spores of many species. With dematiaceous fungi this is rather an advantage, as it minimizes diffraction, but hyaline species, and particularly yeasts, are almost invisible when mounted in plain lactophenol, unless the iris of the microscope is shut down to the point where resolution is quite inadequate. Some method of staining is therefore essential.

The staining methods used for plant sections are mostly inapplicable as they involve too much manipulation, with consequent breakdown of structure. The most suitable stains are those which can be incorporated in lactophenol, the solutions being used as combined staining and mounting fluids. Unfortunately there are very few dyes which will stain from lactophenol. Cotton blue is commonly used in this manner, but, in our experience, it tends to stain very unevenly and it gives far too much 'background colour'. Replacement of the stain with plain lactophenol gives little improvement as the dye is slowly washed out of the specimen. Picric acid stains much more evenly than cotton blue and, although the colour is somewhat pale for visual observation, good photomicrographs may be obtained with the aid of a blue light-filter. Orseillin BB, as recommended by Alcorn and Yeager (1937), does not stain well from lactophenol but gives better results if used in dilute acetic acid, with subsequent replacement of the stain by lactophenol. Orange G can be used in the same way and sometimes gives very good results, but both dyes tend to bleed out into the mounting fluid.

Lactophenol-picro-nigrosin

Aqueous nigrosin does not stain appreciably but has long been used by bacteriologists for the so-called 'relief' or 'negative' staining, and can be so used for fungi (as mentioned above). A combination of picric acid and nigrosin in aqueous solution, usually referred to as picro-nigrosin, has also been known for many years although it appears to have been little used. It stains moulds, albeit slowly, but usually forms a dark precipitate on the slide which is difficult or impossible to remove.

A chance observation by one of us (A. F.) showed that picro-nigrosin in lactophenol stains rapidly and cleanly, and the stain is quite fast in the sense that it is not removed by replacement of the stain with plain lactophenol or by treatment with alcohol or strongly acid reagents. The concentration of nigrosin should be low, to avoid overstaining, and the following method has been found to be satisfactory for most moulds: 2 % of nigrosin (*Bact.* stain) is dissolved in saturated aqueous picric acid. This solution is used in place of the water in compounding lactophenol. The concentration of nigrosin in the moulding fluid is 0·4 %. The specimen is immersed directly into a drop of this solution, or, if difficult to wet, may be first treated with a drop of alcohol and the drop of stain added just before the alcohol has completely evaporated. The specimen may now be teased out as required and a cover-glass applied. This results in a slide with a small but appreciable amount of background colour. A better method is to

allow the stain to act for about half a minute, without teasing out, then suck off the stain with a scrap of filter-paper, add a drop of plain lactophenol to wash away excess stain, remove this and finally tease out and mount in a fresh drop of plain lactophenol. The colour of the stain is almost pure grey and specimens show up well with any colour of light-filter.

Sealing lactophenol mounts

Lactophenol mounts, if handled carefully, will remain in good condition almost indefinitely without sealing. There is, however, always the difficulty of cleaning the surface of the cover-glass without disturbing the specimen, and ringing is always advisable if slides have to be stored.

Brown shellac cement, which can be applied with turntable and brush, is satisfactory provided that the cover-glass is not under strain. It is advisable to allow slides to stand for a few days before ringing as, in this time, any unevenness will show itself.

Another method of sealing, which many workers find preferable, is to use a resin-lanoline mixture or Noyer's cement, applied with a hot wire or glass rod. The method is not difficult provided that square cover-glasses are used, and the results appear to be quite permanent.

The double cover-glass method of Diehl (1929), in which the sealing agent is ordinary balsam, is elegant but gives very disappointing results with most species. The drastic heat treatment involved usually results in complete breakdown of sporing structures, and all stains are destroyed. It has been claimed by Linder (1929) that the method can be used with lactophenol instead of glycerol as mounting fluid, and without the application of heat, provided that the mounts are dehydrated in a desiccator before sealing, but we have had no success with the method. It is to be hoped that someone will succeed in devising a satisfactory technique which does not involve evaporation, as the method in principle is ideal.

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THE BRITISH HYSTERIALES. II

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(With 10 Text-figures)

The majority of the British Hysteriales appear to be rather rare, and some are evidently becoming rarer. *Hysterographium Fraxini*, for example, was reported by Greville (1824) to be 'Very common.... One of the best known and most common' of the Hysteriales; now (*fide* Dr Dennis) it appears to be absent from the vicinity of Edinburgh. Cooke collected enough of it at Highgate, London, in 1868 to distribute as his *Fungi Brit. Exs.* 398; one now looks in vain for it within many miles of London. Indeed, much search by others and myself in various parts of England, during the last few years, has failed to reveal the species. Of course ash (and other) trees are not as plentiful as they used to be, nor their dead and fallen branches. In addition, the atmospheric conditions which now preclude the growth of lichens within miles of smoky centres may possibly restrict the growth of certain Hysteriales also. We know little regarding factors influencing the distribution—and the disappearance—of such fungi. In Manitoba I found *H. Fraxini* to be so common as to serve as an aid in the identification of its host; yet in Michigan, where one might think conditions should be more favourable for the fungus, Lohman remarked (1933) 'collected at Ann Arbor in 1895, but it has not been reported since that date'.

Hysterographium Corda (1842) was based on *H. pulicare* (now returned to *Hysterium*, and generally taken as its type species) and *H. elongatum* (Wahlenb. ex Fr.) Corda. The genus in the modern sense is *Hysterographium* Corda em. de Not., characterized by dark, muriform ascospores. De Notaris (1847) included *H. Fraxini* (Pers. ex Fr.) de Not., and *H. elongatum*.

Sphaeria sulcata Bolton (1789) appears to have been the first British record of the fungus now called *Hysterographium Fraxini*. A type specimen for the name *H. Fraxini* can scarcely be designated until Persoon's herbarium has been examined; but one can take as correct the traditional and generally accepted concept of this species. British collections in Kew Herb. have hysterothecia about 1–2 × 0·5 mm., erumpent through the cortex, rarely superficial on the wood, dull black, sometimes forming 'fairy rings'; asci 125–200 × 25–40 μ, with eight (or fewer) spores; the ascospores (Fig. 1) are irregularly biseriate, 30–50 × 12–20 μ, golden to chestnut brown, surrounded by a hyaline gelatinous envelope, ellipsoid with ends somewhat narrowed, with or without constriction at the centre, having five to ten cross-septa, each locule with none to three longitudinal divisions; paraphyses filiform, branched above and forming a brown epithecium.

Most, or possibly all, of these British collections are on ash branches; but specimens from other countries on *Bignonia*, *Olea*, *Populus*, *Syringa*, and *Viburnum* seem to agree morphologically with the species on *Fraxinus*.

Tulasne (1852) noted accessory structures in these words: 'Plusieurs *Hysterium* possèdent certainement des spermogonies, mais elles sont, en général, assez faciles à confondre avec des productions étrangères au Champignons; on doit cependant reconnaître pour celles de l'*Hysterium Fraxini* Pers., les petites corps lageniformes et très noirs si abondamment semés sur l'aire occupée par ses lirelles, et qui ne renferment plus de spermaties longtemps avant la maturité des spores.'

Hilitzer (1929) described these structures as *Hysteropycnis Fraxini* Hilitzer, 'status conidiophorus *Hysterographii Fraxini*'. Such pycnidia (or spermogonia) are found also in British collections; but I agree with Tulasne that they are of little or no diagnostic value, and generally empty. Lohman (1933) obtained, in cultures from Canadian specimens, pycnidia bearing small spores $4{\cdot}5–5 \times 0{\cdot}8–1{\cdot}2\,\mu$ (Hilitzer found them to be $3–6 \times 1–1{\cdot}5\,\mu$). Lohman obtained hyphal development from these spores, but they resemble spermatia and may possibly have a spermatial function.

European and North American collections of *Hysterographium Fraxini* appear identical. There is little or no evidence that the fungus is parasitic; Rostrup's 'parasitic conidial stage' (see Lind, 1913, as *Myxosporium*) must have belonged to another fungus.

Hysterographium elongatum (Fr.) Corda can be typified by Fries's *Sclero-mycetes Sueciae* 62. This was issued as *Hysterium elongatum* Wahlenb., but, if it be chosen as lectotype, Wahlenberg may be replaced by Fries as author. In the *Systema* (1823) Fries placed *H. elongatum* in Tribus Denudata of *Hysterium*, *H. Fraxini* in Tribus Erumpentia, and stressed that distinction: *H. elongatum* '*Semper ad ligna decorticata Populi, Salicis, Rhamni etc.*' and 'Ab *H. Fraxini* situ superficiali facile dignoscitur'.

Scler. Suec. 62, on weathered, bare wood, has superficial hysterothecia; otherwise the fungus is very similar to *Hysterographium Fraxini*. A hystero-thecium from a Kew specimen of No. 62 had brown ascospores (Fig. 2) $32–49 \times 13–17{\cdot}5\,\mu$, with eight to eleven cross-septa, each locule with none to three longitudinal divisions; the spore-bearing part of the asci was about $125 \times 25\,\mu$, with eight irregularly biseriate spores. A Paris specimen of this number was similar except that the ascospores measured $32–45 \times 10–14\,\mu$. I am not sure that I have ever seen material of *H. elongatum* other than *Scler. Suec.* 62.

It is evident that one should, if possible, have an idea of the characters and range of variability of a species before he examines its type specimen. Material a century old is apt to be poor and scanty now, if not then; furthermore, one must leave as much as possible for generations of myco-logists to follow. If one finds ten good spores to measure and study, and an ascus or two, he can count himself lucky; for these internal characters, omitted from early descriptions, are now the main taxonomic characters. Thus Migula (1913) keys the two species of *Hysterographium* as follows: spores $15–20\,\mu$ wide, *H. Fraxini*; spores to $15\,\mu$ wide, *H. elongatum*. Rehm (1887) considered that *H. elongatum* has hysterothecia generally longer, and spores with more cross-septa, than *H. Fraxini*. Both Rehm and Migula record *H. elongatum* as 'sehr selten'.

Hysterographium elongatum has been reported several times from Britain.

Kew has a dozen British specimens labelled *H. elongatum*, but examination shows that they had been identified without microscopic examination. One specimen proves to be *H. Rousselii*, one is a *Hysterium*, two are *Glonium*, six are *Gloniopsis levantica* (sensu Bisby, 1941). Only one could be *Hysterographium elongatum*: it is from Berkeley's Herbarium, marked 'Rev. I. Keith, Forres [Scotland]', and consists of a bit of decorticated branch of ?*Acer* with superficial hysterothecia 0·5–2 mm. long, asci about 150 μ long, ascospores 35–45 × 12–15 μ, with seven to ten cross-septa, each locule with none to two longitudinal divisions.

Apart from the classical distinction that *Hysterographium elongatum* is superficial on bare wood of various dicotyledonous trees and shrubs, *H. Fraxini* erumpent and generally on ash, there seems to be no good character to separate the two. Possibly the spores of *H. Fraxini* are somewhat lighter brown (more golden) and may be, on the average, fewer septate and slightly broader than those of *H. elongatum*, if the species are really distinct. There is apparently no definite record of *H. elongatum* in North America (Bisby, 1932), though *H. flexuosum* is similar except in having spores generally larger (40–63 × 12–20 μ). *H. Rehmianum* Sacc., in alpine areas in Europe, is apparently very similar to *H. elongatum*. It seems to me that the unequivocal species *H. Fraxini* should be considered the type of *Hysterographium*, and the only large-spored member of the genus known in Britain.

Hysterographium Rousselii (de Not.) Sacc. has been collected in Britain only twice, so far as I know. Kew has a specimen marked by Currey '*Hysterium*. Blackheath Dec. 1858, handsome spores', filed (as noted above) in the *Hysterographium elongatum* folder. Then on 7 December 1940, F. Rilstone collected *H. Rousselii* on decorticated *Populus*, Parranzabuloe, Cornwall. He promptly sent me material, but the hysterothecia were too old to discharge ascospores, so I did not obtain cultures.

This fungus, generally called *Hysterographium Rousselii* in Europe and (following Ellis & Evenhart, 1892), *H. Mori* (Schw.) Rehm in North America and China (Teng, 1933), usually occurs on decorticated wood, has hysterothecia about 1 × 0·3 mm. (i.e. smaller than those of *H. Fraxini*), asci about 100 × 10–15 μ, ascospores (Fig. 3) 15–25 (30) × 7–10 μ, brown, with three to five (seven) cross-septa and (none) one to three or four cells with longitudinal divisions, somewhat constricted at the centre. Although rare in Britain, it is rather common in parts of North America, including Manitoba. Lohman (1933) reported that cultures produced pycnidia with spores 2–4 × 1–2 μ.

Glonium Mühlenb. ex Fr. is based on *G. stellatum* Mühlenb. ex Fr., a North American species with long hysterothecia radiating upon a thick subiculum. The British species lack such a subiculum, and so belong to the subgenus *Psiloglonium* Höhnel, which Petrak raised to generic rank.

Glonium varium (Fr.) Sacc. has been twice reported (as *Hysterium*) from Britain. Greville's specimen (1826, pl. 233) from Carmichael is now known as *Farlowiella Carmichaeliana* (Berk.) Sacc. (see Mason, 1941). Berkeley and Broome (1866) reported and figured '*Hysterium varium*' on decorticated

branches of yew, Wynd Cliff [near Ludlow?], but no such specimen was found in Berkeley's Herbarium at Kew. There is, however, a specimen marked by Berkeley '*Hyst. varium*, Acacia, Gopsal. Rev. A. B.' with very little fungus on it; Massee has a figure of a three-septate spore beside the specimen, marked 'brown, =*Hysterium*'. There seems to be considerable doubt as to the identity of *Glonium varium*. Rehm made it a *Tryblidiella*. We can scarcely call it a British fungus without more evidence.

Glonium amplum (Berk. & Br.) Duby was first described by Berkeley and Broome (1854) as follows: '782. *Aylographum amplum*, n.s. Peritheciis congregatis congestive subdepressis furcatus ramosisque. On decaying stems of *Rubi*, Twycross, Rev. A. Bloxam. Distinguished by the perithecia being crowded together in the most perfect specimens and by their comparatively large size [for an *Aulographum*]. Those before us are not so perfect as could be wished, but the species is unrecorded, and the genus new to this country'.

There are ten 'specimens' of *Glonium amplum* in Kew. The only one marked 'Herb. Berk.' is also marked '1856', so can scarcely be the type. All collections are apparently by 'Bloxam, from Orton Wood, near Twycross, Leicestershire, on decaying stumps', to give a summation of the labels. I have examined a hysterothecium or two from each of eight of these specimens, and believe this is the story: about 1854 Bloxam collected a fair amount of material and sent some of it to Berkeley who reported it as new, but 'not so perfect'; it was immature. About 1856 Bloxam went back to his stump ('on *Rubi*' was probably an error) and found more, but these later specimens were past maturity. Then or meanwhile Bloxam shared his specimens with mycological friends, as was his custom. The ten parts of *G. amplum* now accumulated in Kew Herbarium represent, I believe, one ample fruiting of this perennial fungus.

The hysterothecia are crowded, 0·5–1 × 0·3–0·5 mm., dull black, with a longitudinal groove; a thin subiculum of brown hyphae is visible in places; asci cylindrical-clavate, about 100 × 10 μ; immature ascospores (Fig. 4) one to two seriate, hyaline to pale yellow, two-celled, 18–22 × 5–6 μ; old hysterothecia show a few clear brown ascospores. Massee (1895) also reports brown ascospores.

The status of *Glonium amplum* remains uncertain. Rehm (1887) and Migula (1913) report it, but their descriptions suggest that they had some other species. If the spores normally become brown, *G. amplum* may belong to *Bulliardiella* (Sacc.) Paoli; the hysterothecia of *B. sphaeroides* (Karst.) Rehm illustrated by Lohman (1938) appear very similar, though its ascospores are somewhat shorter.

Glonium lineare (Fr.) de Not. (the type species of *Psiloglonium*) was distributed by Fries as *Scler. Suec.* 90. There are two examples of this number at Kew: one consists of two parts of a branch bearing semi-immersed, inconspicuous, narrow hysterothecia, 1–2 mm. long, or longer by confluence; the asci are eight-spored, about 100 × 10–12 μ; ascospores (Fig. 5) overlapping uniseriate, 12–15 × 5–7 μ, hyaline, two-celled. This agrees with the generally accepted view of *G. lineare*. The second No. 90 has several superficial hysterothecia, evidently of another member of the Hysteriales, but without spores.

The following British specimens in Kew Herb. are rightly labelled *Glonium* (or *Hysterium*) *lineare*: 'Kendal, J. Martindale', used by Cooke for his *Fungi Brit. Exs.* Ser. II, No. 457; 'Shrewsbury, Rev. W. A. Leighton'; 'on a tree in Gopsal, March 1850'. In addition, there are three parts of one or two collections by Leighton, from near Shrewsbury, April 1870, under the name *G. confluens* (Wallr.) Duby, which is now considered a synonym, and a specimen marked '*Hysterium elongatum*, Norths. ex Herb. Berk.'

Glonium lineare is fairly common in North America (Lohman, 1937) and in Europe. Hilitzer (1929) described associated 'pycnidia' as *Hysteropycnis globularis* Hilitz., and Lohman (1933) obtained similar fruit-bodies in cultures from ascospores.

Lophium Fr. is based on *L. mytilinum* Fr. (the full author citation of '(Pers. ex Fr.) Fr.' is somewhat ambiguous, since Fries described the fungus under *Lophium* in the *Systema*). Fries distributed *Scler. Suec.* 60 as '*Hysterium mytilinum* Pers. non hujus generis', meaning that he was about to name it *Lophium*. There are two examples of No. 60 at Kew; the one filed as *L. mytilinum* has only one or two uncertain hysterothecia which I refrained from touching. As Massee (1895) states that he examined No. 60, his description is presumably based at least in part on hysterothecia formerly present. For the second example of No. 60, see *Ostreion* below.

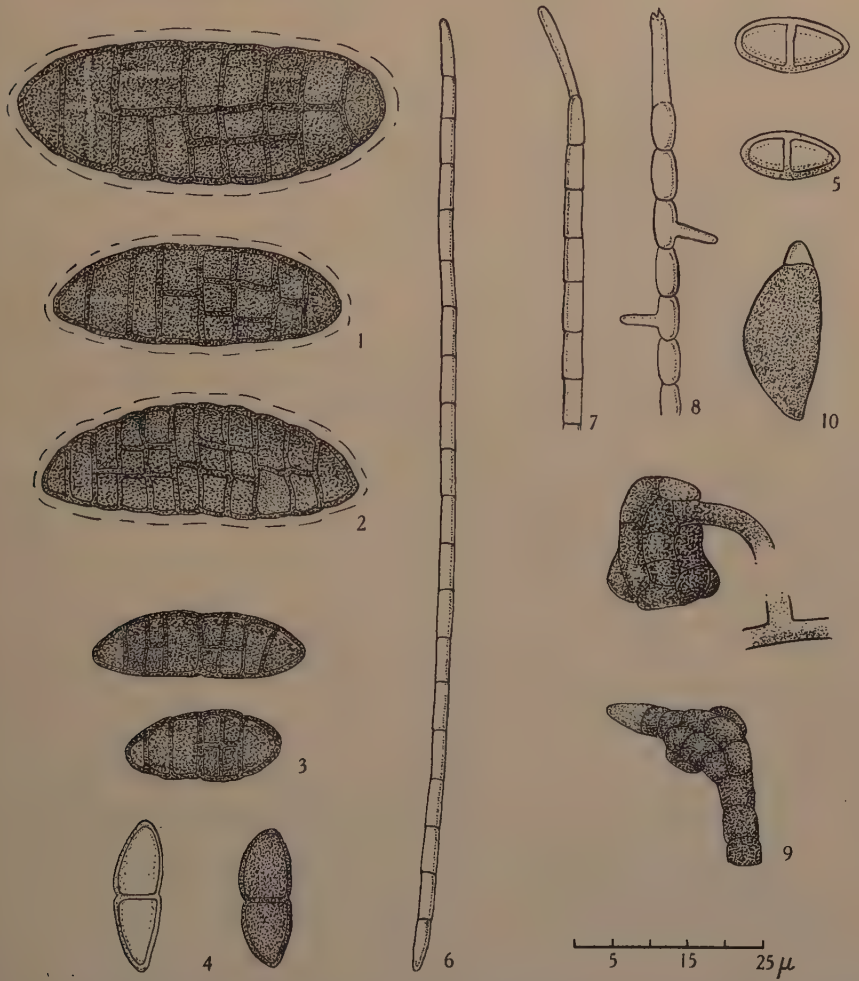
There are three or four British specimens marked *Lophium mytilinum* in Kew Herb., all collected about seventy years ago and all too immature or scanty to study. However, the species can still be found on old wood and bark of conifers. Specimens were sent from Kelnsey, Yorks, coll. W. G. Bramley, 19 September 1940, and from the Scottish Border, coll. R. W. G. Dennis, about April 1941. These have erect mussel-shaped hysterothecia (like those of *Mytilidion* illustrated by Bisby, 1941) 0·5–1 mm. long; asci cylindrical, 130–160 × 7–10 μ; ascospores (Fig. 6) filiform, greenish, 120–140 × 1·5–2 μ, finally fifteen to twenty septate.

Ascospores from both these collections were discharged upon agar and within a few hours at 26° C. germinated from the end cells (Fig. 7). After about thirty-six hours some of the other cells, all of which had become swollen, put out germ tubes (Fig. 8). An olivaceous mycelium developed which soon produced numerous aggregations of hyphal cells (Fig. 9), the so-called '*Papulaspora mytilina* (Pers.) Lohman' (1933). Lohman found pycnidia with spermatium-like spores in his cultures, a state I did not definitely find in mine.

Lophium elatum Grev. (1825) has been collected but once in Britain. Massee (1895) redescribed part of the type, with ascospores about 200 μ long. Little fungus now remains on this specimen at Kew, but from its appearance, Greville's figures, and the descriptions I think it is not a *Lophium*, but possibly an *Acrospermum*. The fungus which Desmazières issued as *Lophium elatum* Grev. in *Crypt. France* 1530 appears similar externally, and contains filiform spores, but I did not see an ascus.

Ostreion was reported as British by Massee (1895), and he filed three British specimens, and one example of Fries's *Scler. Suec.* 60, as *O. ameri-*

canum Duby. This No. 60 has no good hysterothecium left on it and, despite Massee's appended drawings of spores of *Ostreion*, it seems most unlikely that it ever bore *O. americanum*. No spores were found in the



Figs. 1–10. 1. Two ascospores of *Hysterographium Fraxini* from Cooke's *Fungi Brit. Exs.* 398. The paler lines represent partial septa not clearly visible. 2. An ascospore of *H. elongatum* from *Scler. Suec.* 62. 3. Ascospores of *H. Rousselii*, showing some of their variation. One is from the 1858 collection, one from the 1940. 4. Spores of *Glonium amplum*. 5. *G. lineare*, one spore from the Kendal collection, one from Fries's *Scler. Suec.* 90. 6. Ascospore of *Lophium mytilinum* from Yorkshire. 7. Ibid., early stage of germination. 8. Ibid., after 36 hours on agar. 9. Ibid., two of the various *Papulaspora*-like aggregations of cells. 10. Ascospore of *Farlowiella Carmichaeliana*. All × 1000.

British specimens (from Aboyne, Twycross, and Gopsall), but the one from Gopsall has a sketch by Berkeley which suggests *Lophium* or *Mytilidion*. Massee seems to be the only one to have reported *Ostreion* from Europe,

but almost certainly in error. *O. americanum* has, however, been recorded in China (Teng, 1933).

Farlowiella (Fig. 10) has been studied by Mason (1941), who finds that there is one species, *F. Carmichaeliana* (Berk.) Sacc., with the synonym *F. repanda* (Duby) Sacc.

General discussion and summary

Modern students of Ascomycetes are inclined to restrict the order Hysteriales to lignicolous or corticolous fungi with superficial or erumpent, black, carbonaceous or membranous, elongate hysterothecia. All such Hysteriales recorded in Britain to date are now summarized.

Dichaena: none of the three species recorded here is definitely known to be an Ascomycete.

Farlowiella has been reported from three collections in Britain: before 1826, about 1855, and in May 1936. There is also a report of it from Belgium. Its conidial state has, however, been recorded across Europe to Italy.

Gloniopsis has been identified in Britain under six specific names, but I consider that there is only one British species, *G. levantica* Rehm—commonly, but apparently erroneously, called *G. curvata* (Fr.) Sacc. (The material upon which the British record of *G. biformis* (Fr.) Sacc. was based has now been examined; it too is *G. levantica*.)

Glonium lineare has been found several times, but I have seen no British specimen collected during the last half-century. *G. amplum* is known only from immature and over-ripe specimens collected in one locality ninety years ago.

Hysterium pulicare Fr. and *H. angustatum* (Fr.) Chev. are not uncommon in Britain. The two collections of *H. acuminatum* Fr. recently reported date from the last century.

Hysterographium Fraxini was formerly common. The last record is apparently that of the Aviemore Foray in 1927. *H. elongatum* is a similar species not definitely known in Britain. *H. Rousselii* has been collected in 1858 and 1940.

Lophium is represented by *L. mytilinum*, which is perhaps not rare on conifers.

Mytilidion laeviusculum (Karst.) Sacc. is known in Britain from one collection made sixty years ago. It was on a piece of board, with which it was possibly introduced. *M. gemmigenum* Fuckel has been recognized five or six times. *M. Karstenii* Sacc. was first reported here in 1941.

Ostreion is evidently not a British fungus.

The British Hysteriales on wood and bark were reported, in the literature up to 1940, under twenty-five specific names. In working over the specimens I have added two names and subtracted fourteen, leaving thirteen species that are, in my opinion, 'good'. Only nine of these are known to me from Britain since the twentieth century began.

More collections are needed to indicate not only the distribution, but even the occurrence, of various Hysteriales in the British Isles. While personal experience has shown that it is likely to be discouraging to make Hysteriales the primary object of a collecting trip, most of those found will be identifiable. They are to be sought on bark of trunks or branches of coniferous or dicotyledonous trees or shrubs, or on bare wood of branches, chips, posts, etc. Collections can be made in any month, since the hysterothecia are evidently perennial, though little is known of their time cycles; perhaps some species are biennial or even annual. About one in four collections will be too immature or too old to provide good ascospores. Since early mycologists identified these fungi on hysterothecial characters, such young or exolete specimens will be found in herbaria—sometimes even as types—and of course many collections with spores will be found misidentified.

Knowledge of the life cycles of a number of Hysteriales has been extended in recent years by cultures from ascospores and by observations in the field. Most of the imperfect states are rather nondescript. Those to which Hilitzer gave *Hysteropycnis* names resemble spermatial states, and one may suspend judgment as to their function until someone succeeds in developing hysterothecia in culture. *Mytilidion Karstenii* has a *Septonema* state that may be unnamed and, barring the improbable chance that it should prove important, scarcely needs a name; the Rules of Botanical Nomenclature specify that a species should bear but one name, that of its perfect state (if known). The most noteworthy of the known conidial states of Hysteriales is perhaps *Monotospora megalospora* Berk. & Br., demonstrated by Mason to belong to *Farlowiella*.

This key is based on the true Hysteriales recognized by the writer as occurring in Britain now or formerly. It may be noted that species with erect hysterothecia are on conifers; others, except *Hysterium acuminatum*, are on woody dicotyledons. The word 'spores' refers to ascospores.

Hysterothecia erect, mussel-shaped; on conifers:

With pale scolecospores	*Lophium*
Spores 100–150 × 1·5–2 μ	*L. mytilinum*
With brown phragmospores	*Mytilidion*
Spores 16–22 × 2·5–3 μ, 1–3-septate	*M. laeviusculum*
Spores 28–42 × 3·5–4 μ, 3–4-septate	*M. Karstenii*
Spores 30–40 × 5–7 μ, 7–9-septate	*M. gemmigenum*

Hysterothecia flatter, navicular to elongate:

With brown amerospores, each with papilla	*Farlowiella*
One species; spores 18–27 × 7–12 μ	*F. Carmichaeliana*
With hyaline didymospores	*Glonium*
Spores 12–14 × 5–7 μ	*G. lineare*
Spores 18–22 × 5–6 μ, becoming brown?	*?G. amplum*

With brown phragmospores (4-celled here)	*Hysterium*
Spores 12–18 × 5–6 μ, on conifers	*H. acuminatum*
Spores 15–24 × 5–7 μ, on hardwoods	*H. angustatum*
Spores 18–35 × 6–10 μ, end cells paler	*H. pulicare*
With hyaline dictyospores	*Gloniopsis*
Spores 15–30 × 6–10 μ	*G. levantica*
With brown dictyospores	*Hysterographium*
Spores 30–50 × 12–20 μ	*H. Fraxini*
Spores 15–30 × 7–10 μ	*H. Rousselii*

Once more the writer acknowledges his thanks to the authorities of the Royal Botanic Gardens, Kew, to E. W. Mason for suggestions, and to those who have contributed specimens.

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Addendum. Zogg (*Phytopath. Z.* xiv, 310–84, 1943; see *Rev. appl. Mycol.* xxii, p. 504) now reports the development of asci in cultures from single ascospores of *Hysterographium Fraxini*, mycelium but not asci from microconidia. He recognizes only five species in the genus, and uses the name *H. Mori* for the species heretofore called *H. Rousselii* in Europe.

THE DEVELOPMENT OF *LYSURUS SULCATUS* (COOKE & MASSEE)

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(With Plates I and II and 1 Text-figure)

1. Introduction

The mature fructification of *Lysurus sulcatus* is described by Cunningham (1931). The main features of this fungus are as follows: a white subglobose peridium about 3 cm. in diameter; a receptacle comprised of a hollow stem 15 × 2 cm., white below, cream-buff above and divided apically into five to seven arms which are erect, hollow, narrow-lanceolate, 10–30 mm. long and apically attenuate; gleba is borne on the inner surface and edges of the arms, brownish-mucilaginous and fetid (Pl. I, fig. 4): spores elliptical, smooth, and hyaline, measuring 4·5–5 × 1·5–2 μ.

Cunningham (1931) has placed the genus *Lysurus*, together with the genera *Anthurus* and *Aseroe*, in the tribe Stellateae of the family Clathraceae. Development in species of *Clathrus* and *Clathrella* of the tribe Clathrateae, and *Aseroe rubra* of the Stellateae has been worked out by Fischer (1890). Some stages in the development of the Chinese *Lysurus Mokusin* were described by Cibot and Fischer (Fischer, 1893). So far as I am aware, the complete development of *Lysurus sulcatus*, one of the most common phalloids in Australia, has not been described previously.

A large quantity of material suitable for the study of the development of this fungus was found by me at Canberra in March 1939. The material consisted of all stages of egg development, found about 2 cm. below soil surface, as well as many specimens of the mature fructification. Some of the stages of the developing egg are shown in Pl. I, fig. 1. The specimens were fixed in formol-acetic-alcohol, embedded, and sectioned at 7 μ. The sections were stained with either Orseillin BB or iron-alum haematoxylin.

2. Development of the egg

The young fructifications are first observed as small white swellings on the end of rhizomorphic strands (Pl. I, fig. 1). These are the primordia of the sporophores, and when about 1–1·5 mm. in diameter they show an internal differentiation into a loose cortex, and a dense medulla which stains deeply (Pl. II, fig. 1). With increase in size there is a differentiation of the tissues within the egg which takes place progressively towards the centre. There is first a differentiation of the volva-gel, then of the gleba, and finally of the receptacle. The fundaments of these tissues appear when the egg is very small.

The fundament of the volva-gel is differentiated from the medulla by

proliferation of groups of cells into five to seven lobes of loose tissue. These lobes are equal in size and are separated by undifferentiated tissue of the cortex. The lobes enlarge equally and compress the undifferentiated cortical tissue into strips of intermediate tissue (Pl. II, figs. 2, 2B). These later become the peridial plates of the mature egg. By the time the egg is 3 mm. in diameter, clefts appear at the junction of the intermediate tissue and the medulla, and the medulla surrounding these clefts is lined with a layer of palisade tissue. This constitutes the fundament of the gleba (Pl. II, figs. 2, 2A).

Rapid tissue development in the palisade layer causes folding of the medulla within the clefts, and displacement of the volva-gel towards the periphery. At this stage the intermediate tissue lying in the cleft cavity forms thickened hyphal knots. These are the fundaments of the receptacle arms (Pl. II, figs. 3, 3A). The intermediate tissue below the mass of medullary tissue and continuous with the rhizomorph also becomes thickened, and is the origin of the stem of the receptacle (Pl. II, fig. 2B). The thickened intermediate tissue soon becomes pseudoparenchymatous. These receptacle parts can be clearly seen in longitudinal sections of the egg (Pl. II, fig. 4B) when about 6 mm. in diameter.

The complete transformation of the medulla into glebal tissue results in an increase in bulk of the gleba which occupies the central region of the egg. The glebal tissue consists of the gelatinized columella, and the trama plates which have developed as a result of folding of the palisade layers of the medulla (Pl. II, figs. 4, 4A, 4B). At this stage the tramal plates are lined with the hymenium and sporogenesis follows (Pl. II, fig. 4A). The increase in glebal tissues tends to flatten peripherally the volva-gel, causing some distortion of the peridial plates which are derived from the intermediate tissue. These plates break up the gelatinized volva-gel into areas corresponding in number with the receptacle arms.

Further gelatinization of the volva-gel and gleba, together with increase in tramal tissue, and development of the pseudoparenchyma of the receptacle bring about a much greater increase in size of the egg until the mature stage is reached. As maturity is approached there is much folding of the pseudoparenchymatous tissue in the walls of the receptacle and receptacle arms, and a groove is formed along the mid-line on the outer side of each receptacle arm (Pl. II, figs. 5, 6). The tramal plates become narrow and more tortuous (Pl. II, figs. 5, 5A); and the glebal chambers are partially filled with spores which are produced continuously from the hymenial layer.

The mature egg seen in section in Pl. I, fig. 3, consists of an exoperidium (*E*) enclosing the gelatinous mesoperidium or volva-gel (*VG*), broken up into chambers by peridial plates (*PP*), corresponding in number to the receptacle arms (*RA*). The endoperidium encloses the gleba (*G*) and receptacle arms towards the apex of the volva, and the receptacle stem (*RS*) towards the base. The volva-gel completely encloses these central tissues which are to become the main feature of the mature fructification. It will be seen then that of the structures found in the mature egg the cortex of the primordium gives rise to the exoperidium, peridial plates of the volva,

and the receptacle; from the medulla is derived the mesoperidium or volva-gel, and the gleba.

3. Maturation of the fructification

The peridium is ruptured by increased turgor of the receptacle, which rapidly expands, carrying the gleba free of the volva, and, as reported by Cleland and Cheel (1917), the receptacle is held in position in the volva by the peridial plates. When the fructification first emerges from the volva the gleba is firm and does not emit the fetid odour characteristic of the mature gleba. However, soon after the receptacle has fully expanded, which takes from one to several hours, the fetid odour is noticed. This odour appears to be due to autolysis of the mucilaginous tissue of the gleba, for with the occurrence of the odour there is softening of the gleba. Furthermore, I sampled glebal tissue from the unruptured mature egg, from the fructification just after emergence, and from the fructification after the fetid odour became apparent, and then tested the tissue for the presence of free ammonia, reducing substances, amines, skatol and indole. Tests made on the gleba from the unruptured egg and immediately after emergence gave negative reactions, but positive reactions were obtained for free ammonia, reducing substances, and trimethylamine on the gleba sampled after the fetid odour was emitted; the tests for indole and skatol were also negative for this sample. Investigations have so far indicated that ammonia is invariably produced as the result of autolysis in fungi.

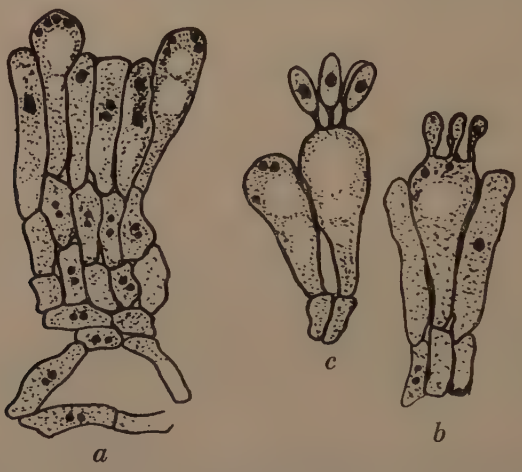
With the softening of the gleba, the arms of the receptacle separate and expose a maximum surface to the agents of spore dispersal. The fetid odour attracts flies, which feed upon the gleba and thus ensure the dissemination of spores.

4. Cytology and sporogenesis

The hyphae in all parts of the developing fructification are binucleate and septate. The dicaryons are most clearly seen in the loose strands of hyphae in the developing volva-gel (Pl. II, fig. 8). Clamp connexions are abundant in all tissues during the earlier phases of development (Pl. II, fig. 8).

Sporogenesis begins soon after the tramal plates are formed when the egg is still only 5–6 mm. in diameter. Text-fig. 1 shows some of the stages in sporogenesis. The dicaryons may be seen in the hyphae beneath the hymenial layer (Text-fig. 1 *a*). In the young basidium caryogamy of the dicaryons occurs, and is soon followed by two divisions resulting in four nuclei usually situated near the apex of the vacuolated basidium. The development of the spores is first seen in four outgrowths on top of the basidium (Text-fig. 1 *b*). One nucleus passes into each of these, which is followed by an increase in the cytoplasmic contents and the formation of the spore wall. Each basidium produces four spores and the spores are connected to the basidium by sterigmata (Text-fig. 1 *c*). The spores are uninucleate and remain uninucleate even after the fructification has

reached maturity (Pl. II, fig. 7). Examination of spores kept on a dry specimen for six months revealed that they were still uninucleate.



Text-fig. 1. Hymenium of *L. sulcatus* during sporogenesis. Drawings made with the aid of a camera lucida. (*a*) Nuclear changes in the young basidia, (*b*) development of spores on the basidium, (*c*) mature spores on a basidium.

5. Discussion

It is apparent that the ontogeny of *Lysurus sulcatus* conforms with the essential features found in the development of other members of the Clathraceae. These are: (i) the direction of growth of the tramal plates is centrifugal from the medulla; (ii) the exoperidium, peridial plates and receptacle take origin from the cortex, and the volva-gel and gleba are derived from the medulla of the primordium of the fructification; and (iii) the gleba develops inside the receptacle or receptacle arms.

Differences in developmental features between *Lysurus sulcatus* and members of the Clathraceae so far studied, appear to be in the position and size of the volva-gel lobes differentiated from the medulla. In *Clathrus* and *Clathrella* the lobes are numerous, unequal in size, and are arranged near the apex of the egg, while in *Lysurus sulcatus*, they are limited to five or seven lobes, equal in size, and occupy equally the space surrounding the medulla of the egg, like the segments in an orange (Pl. II, figs. 2, 2B). Another difference is seen in the development of a receptacle stem in *Lysurus* which is derived from the intermediate tissue between the volva-gel lobes and below the medulla. Finally, there is no formation of chambers in the arms of the receptacle by gelatinization of the intermediate tissue enclosed by the arms of the receptacle as in *Clathrus* and *Clathrella*.

On the basis of morphological features of the receptacle arms, *Lysurus* is placed between the genera *Anthurus* and *Aseroe* in the Stellateae. *Aseroe* is considered the most highly evolved form of this tribe because the receptacle arms in *Anthurus* are organically united apically, in *Lysurus* they

are apically free but connivent, and in *Aseroe* they are horizontally expanded. Unfortunately the development of *Anthurus* has not been described so that the development of *Lysurus* cannot be compared with that morphologically simpler genus. The development of *Aseroe* differs from that of *Lysurus* chiefly in the modifications of the intermediate tissue and of the gleba of the former. In *Aseroe* the plates of intermediate tissue do not fuse with the exoperidium as they do in *Lysurus*. The tramal plates of the gleba in *Aseroe* arise from the underside of the columella only and not on the vertical sides and branches of the columella as in *Lysurus*. Therefore in *Aseroe* the gleba cannot converge towards the receptacle arms as it does in *Lysurus*; so that in the mature fructification of the former, the gleba is situated on the horizontal disc, leaving the receptacle arms free. However a feature in common to both genera is that in the mature egg the gleba and receptacle are completely surrounded by the volva-gel. In this respect they both differ from the members of the Clathrateae so far studied.

Comparison with the development of *Lysurus Mokusin* can only be referred to a late stage in the development of the egg. At this stage the arms of the receptacle are separated from one another by a mass of tramal tissue in *L. sulcatus*, whereas in *L. Mokusin* the arms of the receptacle lie directly on the columella of the gleba. This difference in the position of the receptacle arms in relation to the glebal tissue is of course reflected in the morphological differences seen in the mature fructification of the two species.

The uninucleate condition of the mature basidiospores of *L. sulcatus* appears to be an exception to the usual binucleate nature of the mature basidiospores of the Gasteromycetes, although the nuclear condition in mature basidiospores of other members of the Phallales has not been reported so far as the writer can ascertain. Cunningham (1927), however, reports uninucleate hyphae and basidiospores in the gasteromycete, *Geaster velutinus*. In *Lysurus sulcatus* the hyphae in all the tissues of the developing fructification are binucleate, therefore it would appear that either the nucleus of the spores divides on germination to give the binucleate condition, or the resulting hyphae from the germinating spores remain uninucleate until fusion occurs by the usual clamp connections with other uninucleate hyphae. A cytological study of the germinating spores would determine this, but so far I have been unable to germinate the spores of this fungus.

Acknowledgement

I gratefully acknowledge my indebtedness to Asst. Prof. J. McLuckie of the Botany School, Sydney University, for the helpful criticism and advice given in the preparation of this paper.

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EXPLANATION OF PLATES I AND II

Plate I

Fig. 1. Stages in the development of the egg of *Lysurus sulcatus*. Slightly less than natural size.
Fig. 2. The mature egg of *Lysurus sulcatus*. ×2.
Fig. 3. The mature egg in longitudinal section showing exoperidium (*E*), volva-gel (*VG*), peridial plate (*PP*), receptacle arm (*RA*), receptacle stem (*RS*) and gleba (*G*). ×2.
Fig. 4. The mature fructification of *Lysurus sulcatus*, slightly less than natural size, showing from right to left the fructification immediately after emergence to senescence.

Plate II

Photo-micrographs of sections of the developing fructification of *Lysurus sulcatus*.

Fig. 1. Longitudinal section primordium, 1 mm. in diameter, showing cortex (*C*), and medulla (*M*). ×12.
Figs. 2, 2 B, 3, 4, 4 B, 5 and 6. Showing differentiation of tissues with a corresponding increase in size of the egg. (*E*) exoperidium, (*VG*) volva-gel, (*MC*) medullary columella, (*PP*) peridial plates, (*IT*) intermediate tissue, (*CC*) cleft cavity, (*GP*) glebal plates, (*HN*) hyphal knots, (*RA*) receptacle arms, (*RS*) receptacle stem, (*RG*) groove in receptacle arms, and (*G*) the gleba. ×6.
Figs. 2, 2 B. Transverse section and longitudinal section respectively of egg, 2 mm. in diameter. Showing differentiation of the palisade layer on the medulla lining the cleft cavities. The shape and size of volva-gel lobes are also seen. ×6.
Fig. 3. Transverse section of egg, 3 mm. in diameter. Showing differentiation of hyphal knots from the intermediate tissue lying in the cleft cavities. Also the folding of palisade layer. ×6.
Fig. 4. Transverse section of egg at the level *a–a* in fig. 4 B, about 5 mm. in diameter. Showing the central columella which replaces the medulla and ramifies the gleba. The displacement of the volva-gel towards the periphery, through gleba development. The receptacle arms in glebal depressions. The peridial plates breaking up the volva-gel. ×6.
Fig. 4 B. Longitudinal section of egg at the same stage as fig. 4. Showing differentiated receptacle stem, and peridial plate attached to receptacle arm. ×6.
Fig. 5. Transverse section of gleba of mature egg. Showing five receptacle arms at periphery of gleba with groove on the midline of the outer side of each receptacle arm. ×6.
Fig. 6. Longitudinal section of lower quarter of mature egg. Showing much folded pseudo-parenchyma of walls of receptacle stem with portion of the gleba at the apex. ×6.
Figs. 2 A, 3 A, 4 A, and 5 A. Series showing the development of the tramal plates and gleba in more detail. ×110.
Fig. 2 A. Shows formation of palisade layer or glebal fundament in fig. 2.
Fig. 3 A. Shows beginning of folding of palisade layer to form tramal plates in fig. 3.
Fig. 4 A. Shows well-developed tramal plates and glebal chambers seen in fig. 4.
Fig. 5 A. Shows the tramal plates and hymenium in the mature gleba in fig. 5.
Fig. 7. Hymenium of fig. 5 A. Oil immersion, showing basidiospores on basidia, and uni-nucleated spores in the glebal cavity. ×485.
Fig. 8. Cytology of hyphae of volva-gel. Oil immersion, showing binucleated septate hyphae with clamp connections. ×485.

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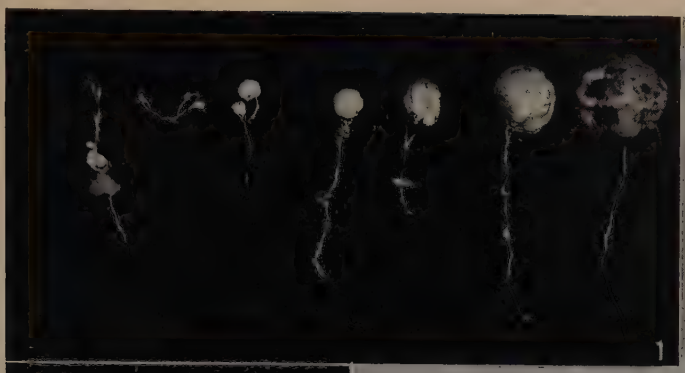
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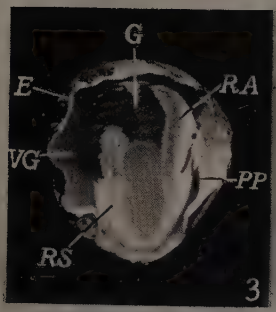
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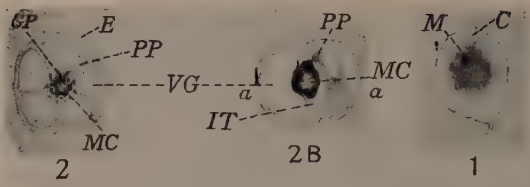
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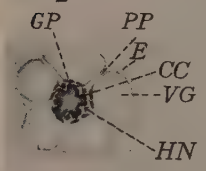
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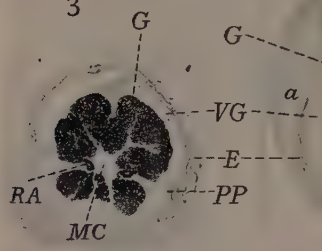
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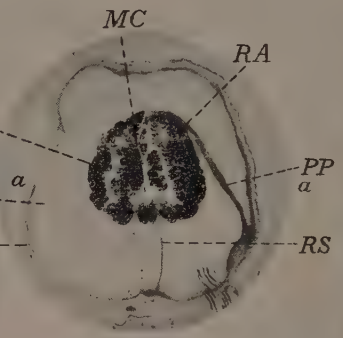
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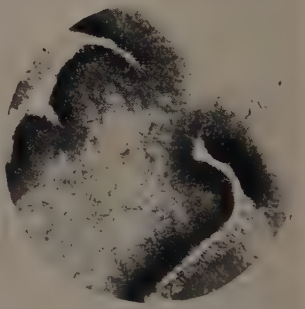
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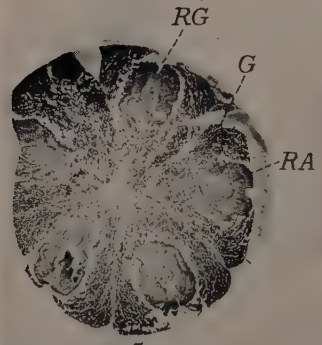
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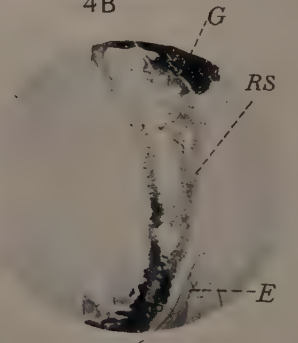
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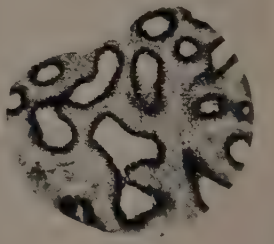
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SOME NEW AQUATIC HYPHOMYCETES

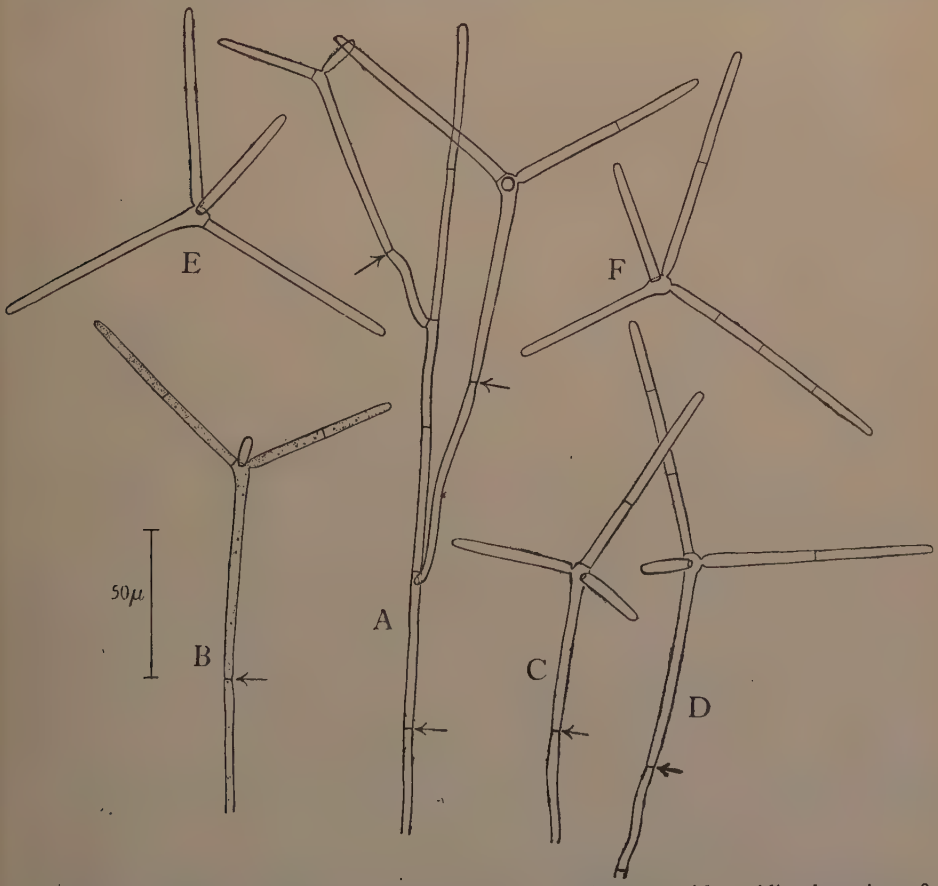
By C. T. INGOLD, *Department of Botany, University College, Leicester*

(With Plates III and IV and 8 Text-figures)

Articulospora inflata n.sp.

Articulospora inflata was found on some of the leaves in each of four separate samples of submerged decaying leaves of oak and sycamore collected during January and February 1943 from a stream in Meanwood Valley, near Leeds.

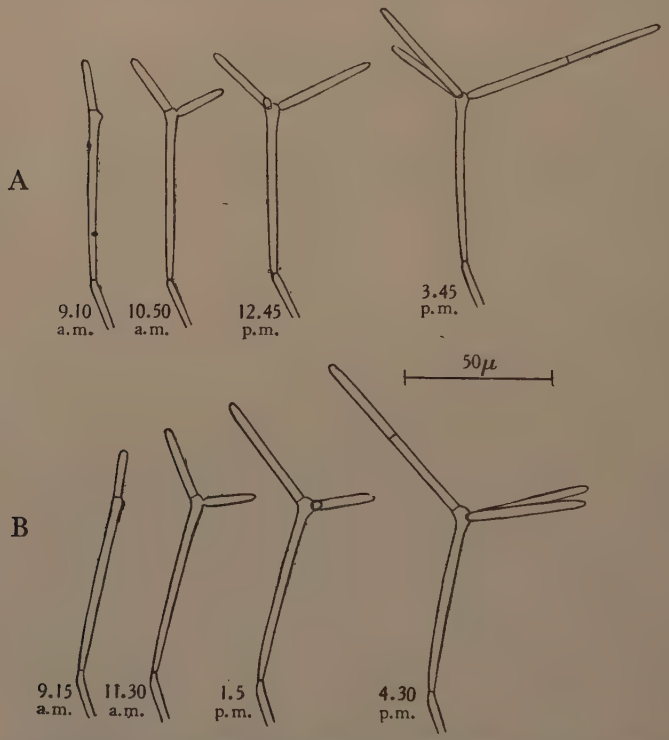
The hyaline conidiophore (Text-fig. 1 and Pl. III, figs. 2, 4 and 5), which juts out into the water at right angles to the decaying tissue, is usually



Text-fig. 1. *Articulospora inflata* n.sp. A, B, C and D, conidiophores with conidia. the points of attachment being indicated by arrows; in B protoplasmic contents are shown. In A the spore on the right is nearly mature, but that on the left is young and the fourth arm has not yet begun to develop. E and F, liberated spores. From decaying oak leaves.

simple, though occasionally branched, and bears a single terminal hyaline conidium of the aleuriospore type, consisting of four long, straight filamentous arms diverging from a common point. When the spore is attached to its conidiophore, one of these arms, the first-formed, is continuous with the conidiophore, the junction being clearly marked by a cross-wall.

At an early stage in development (Text-fig. 2) the spore-primordium is cut off from the conidiophore by a cross-wall as a long straight cell. As it grows longer a wall is formed some way behind the growing apex de-



Text-fig. 2. *Articulospora inflata*. Successive formation of two conidia from the same conidiophore as seen in a hanging-drop. A, the first day; 9.10 a.m. the spore primordium of two cells, the lower (first-formed arm) and the upper (second-formed arm); 10.50 a.m. the third arm has arisen; 12.45 p.m. the fourth arm just appearing; spore shed between 8 and 10 p.m. No observations made during the night. B, the next day; 9.15 a.m. a new spore primordium, very much like that which was formed twenty-four hours earlier, had developed, and further development followed the same course as on the previous day. Spore shed between 9 p.m. and 10 p.m.

limiting a lower cell, the first-formed arm of the spore, from the upper, the second-formed arm. While the apex of the second arm elongates, a slight swelling forms to one side below the wall between the first and second arms, and this leads to flexure of the developing spore here. From the swelling the third-formed arm of the spore buds out and, after it has grown to a length of 15–20 μ, the fourth arm arises close to the third. Where the third and fourth arms arise from the slightly inflated upper part of the

first arm, each is somewhat constricted, but there is no constriction between the first and second arms. The second, third and fourth arms elongate apically until each is 50–120 μ long and frequently exceed the length of the first-formed arm which, more often than not, is the shortest arm of the mature spore. Each arm is usually one- or two-septate.

The spore is liberated by disarticulation at the wall separating the conidium from its conidiophore.

Following the liberation of the spore the apex of the conidiophore may grow out into a straight hypha from which, in due course, a new spore-primordium is cut off. Sometimes the delimiting cross-wall arises at the same level as that which delimited the first spore, so that the spores are really produced in basipetal succession. An example of this is illustrated in Text-fig. 2.

The spores germinate readily in water and a number of pure cultures from single spores have been grown on malt agar. On this medium the fungus forms a compact white or slightly cream-coloured colony with rather dense, low, aerial growth. The colony agrees in colour with that of *Articulospora tetracladia*, but differs in having a very irregular margin. The colony does not form spores, but when strips of the culture are submerged in water, conidiophores bearing conidia form in twenty-four to thirty-six hours. The spores so formed agree with those observed on the leaves, but a few abnormal spores are formed by the branching of one or more of the four divergent branches of the spore (Text-fig. 3, and in Pl. III, fig. 3). Only very rarely have abnormal spores been seen on conidiophores arising from decaying leaves.

The development of the spore, especially the successive origin of the four arms, clearly places the fungus in the genus *Articulospora* of which the only other described species is *A. tetracladia* Ingold. Confusion between the two species is hardly possible, but it may be well to list the essential differences:

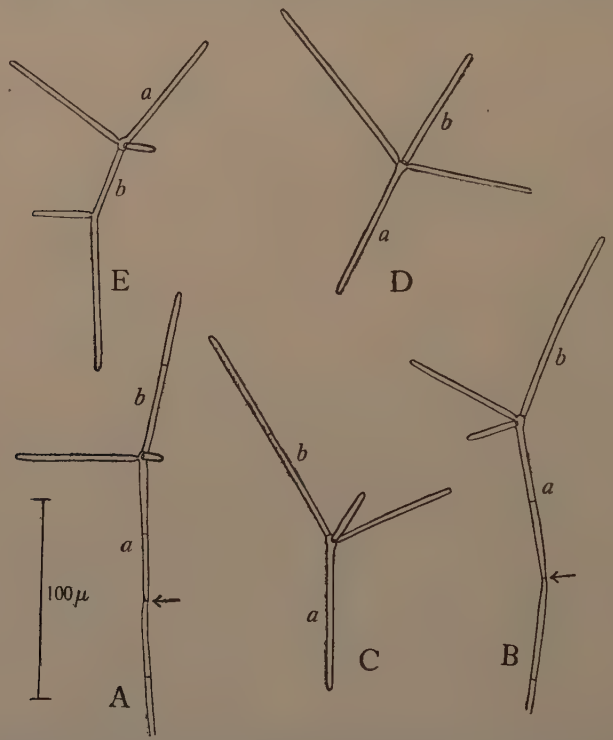
	Articulospora inflata	*Articulospora tetracladia*
1.	Spores larger	Spores smaller
2.	Third and fourth arms of spore constricted at base	Second, third and fourth arms of spore with pronounced basal constrictions
3.	Slight inflation of first arm of spore at point of origin of other arms	No inflation at point of origin of arms of spores
4.	Spores formed singly at apex of conidiophore	Spores formed in succession and side by side at apex of conidiophore
5.	Conidiophore usually unbranched	Conidiophore usually branched

Of the two species, *A. tetracladia* seems to be much the commoner. A large number of samples of submerged decaying leaves have been examined from streams in many parts of Britain, and in most of these samples *A. tetracladia* has been found abundantly, but *A. inflata* is known only from the stream in Meanwood Valley, although there it seems to be quite common. *A. tetracladia* is abundant in the same locality.

The specific epithet is suggested by the inflated region of the first arm from which the other arms diverge.

Articulospora inflata n.sp.

Submerged aquatic fungus with branched, septate, hyaline mycelium. Conidiophore usually simple, 40–50 μ long, 3–4 μ broad, sometimes sparingly branched. Conidia (aleuriospores) hyaline, terminal, solitary, septate, quadraradiate; first-formed arm continuous with the conidiophore, 50–70 μ long, 3–4 μ wide, with the uppermost region (from which the other arms arise) slightly inflated; second-formed arm not constricted



Text-fig. 3. *Articulospora inflata*. A and B, conidiophores with nearly ripe conidia (arrows indicate the point of junction); C and D, normal spores; E, abnormal spore. In each spore *a* indicates the first-formed arm and *b* the second-formed arm. It is only by following development that the third and fourth arms can be distinguished from each other. All from pure culture.

at its base, 50–120 μ long, 3–4 μ broad; third and fourth arms 50–120 μ long, 3–4 μ broad, constricted at the base to 1·5–2 μ. On submerged decaying leaves of sycamore and oak from a stream near Leeds, England.

Articulospora inflata sp.nov.

Fungus aquaticus submersus, mycelio repente ramoso, septato, hyalino. Conidiophora plerumque simplicia, 40–50 μ longa, 3–4 μ lata, interdum parce ramosa. Conidia (aleuriosporae) hyalina, acrogena, solitaria, septata, quadraradiata; ramus primo evolutus cum conidiophoro continuus, 50–70 μ longus, 3–4 μ latus, summa parte (unde ceteri rami exoriuntur) parce inflata; ramus secundus ad basim non constrictus,

50–120 μ longus, 3–4 μ latus; ramus tertius et quartus 50–120 μ longi, 3–4 μ lati, ad basim constricti ad 1·5–2 μ.

Hab. in foliis putrescentibus *Quercus* sp. et *Aceris* sp. in flumine jacente prope Leeds, Anglia.

Tricladium gracile n.sp.

Tricladium gracile (Text-fig. 4) has been observed frequently on submerged decaying leaves from various parts of Leicestershire, and on similar leaves from the neighbourhood of Reading, Leeds, Frome and Anglesey. It seems to be common on submerged leaves decaying in well-aerated water.

The conidiophores, which project from the petioles and larger veins of the decaying leaves, are simple, 10–50 μ long, 2–2·5 μ broad, and each bears a single terminal conidium. This consists of a long main axis with two lateral branches. The main axis is 90–150 μ long with its lower half 3·0–3·5 μ wide, but the upper half gradually tapers until near its tip it is only 1·5 μ wide. The main axis is bent or curved so that it does not occupy a single plane and a fairly abrupt curvature is usually associated with the points of origin of the two laterals. The laterals are long (50–80 μ) and narrow (1·5 μ). They do not taper and their bases are not appreciably constricted.

Of the three other species so far described (Ingold, 1942, 1943), *T. gracile* might be most easily confused with *T. angulatum*, but there are clear and consistent differences, namely:

	Tricladium angulatum	*Tricladium gracile*
1.	Nearly mature conidium usually accompanied by a younger conidium	Conidium always solitary
2.	Lateral branch 3–4 μ wide at the base, tapering to 1·5–2·0 μ near apex	Lateral branch uniform in width, not tapering

T. gracile has not yet been isolated in pure culture.

The specific epithet (Lat. *gracilis*, slender) is suggested by the slender lateral branches of the spore.

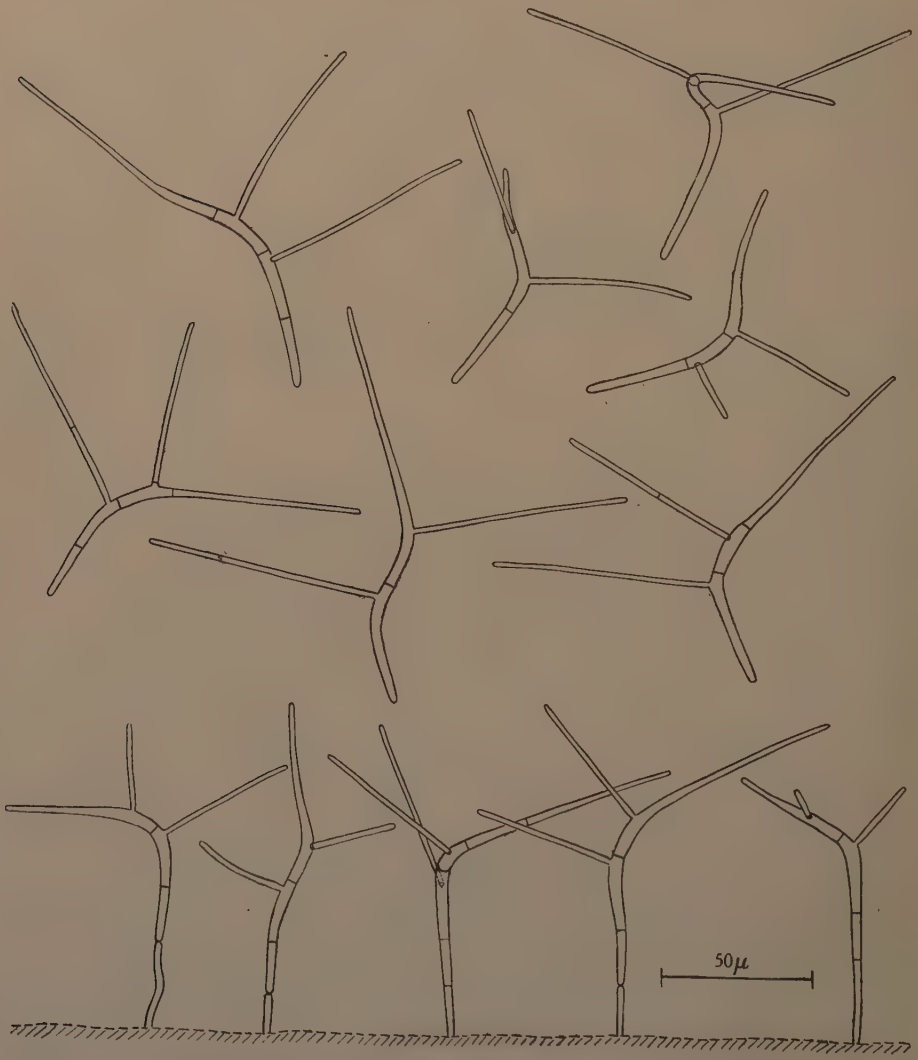
Tricladium gracile n.sp.

Submerged aquatic fungus with branched, septate mycelium. Conidiophores simple, hyaline, 10–50 μ long, 2–2·5 μ broad. Conidia (aleuriospores) terminal, solitary, hyaline, septate, branched, consisting of a main axis and two branches; main axis 90–150 μ long, 3·0–3·5 μ broad in the basal half, but tapering to 1·5 μ towards the apex, curved or bent to an obtuse angle at the point of origin of each lateral branch; branches straight, 50–80 μ long, 1·5 μ broad; distance between the points of origin of the two branches 14–18 μ. From submerged decaying leaves of oak from streams in Britain.

Tricladium gracile sp.nov.

Fungus aquaticus submersus, mycelio repente ramoso, septato. Conidiophora simplicia, hyalina, 10–50 μ longa, 2–2·5 μ lata. Conidia (aleurio-

sporae) acrogena, solitaria, hyalina, septata, ramosa, ex axe principali et ramis duobus composita; axis principalis 90–150 μ longus, parte inferiori ad 3·0–3·5 μ latus, apicem versus ad 1·5 μ attenuatus plerumque curvulus



Text-fig. 4. *Tricladium gracile* n.sp. Above: seven liberated spores. Below: conidiophores; in all five the junction between the conidium and its conidiophore is probably the second cross-wall below the lower branch of the conidium; in three disjunction of the conidium from its conidiophore has begun. Substratum shown diagrammatically.

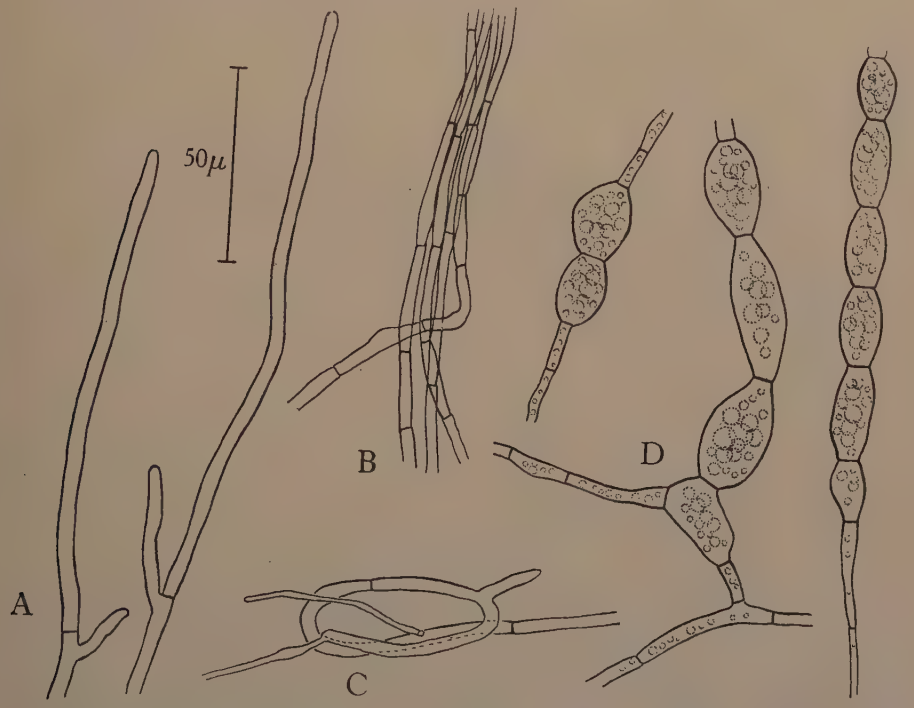
vel iisdem locis e quibus rami oriuntur obtuse angulatus; rami recti, 50–80 μ longi, 1·5 μ lati; rami e locis 14–18 μ separatis orientes.

Hab. in foliis putrescentibus *Quercus* sp. in fluminibus in Britannia.

Flagellospora penicillioides n.sp.

Flagellospora penicillioides (Text-figs. 5–7 and Pl. IV, figs. 4–7) was found on a submerged decaying leaf from the River Loddon at Swallowfield near Reading. The leaf was so rotten that it could not be identified.

The mycelium grew within the leaf and the conidiophores jutted out at right angles into the water. Only about a dozen conidiophores were observed. The fungus was obtained in pure culture from single spores. The account given here is based on a study of the fungus in culture, but the conidiophores seen on the decaying leaf were just like those produced in water from pure cultures in the laboratory.



Text-fig. 5. *Flagellospora penicillioides* n.sp. Details of pure culture on malt agar. A, leading hyphae of the growing margin on, or just below, the surface of the agar; hyphae hyaline; no contents shown. B, small part of mycelial cord from the aerial part of the mycelium; bright brown; cell contents not shown. C, simple hypha-coil from aerial mycelium; bright brown; cell contents not shown. D, 'chlamydospores' bright brown with oil-drops indicated.

The fungus grows well on malt agar and these branched, ptate mycelium forms a compact colony. The hyphae (Text-fig. 5) are colourless at first, but soon turn rust-brown. There is much low aerial growth of rusty hue in which some of the finer hyphae form intercalary hyphal coils and the stouter hyphae aggregate into mycelial cords each with two to ten parallel strands. In this aerial growth, individual cells, in certain regions, swell up and become ovoid so that intercalary chains of spore-like cells are formed. All the cells of the old mycelium have abundant oil-drops, but the swollen

cells are especially rich in oil. Perhaps these cells are chlamydospores. When the fungus is grown on agar slopes in test tubes, small aggregates of these chlamydospores occur, where the medium joins the glass, forming small sclerotia.

The colony on malt agar forms few or no conidiophores but, if a small strip is cut out and submerged in water, very numerous submerged conidiophores are produced within two days. Further, at the cut surface of the agar produced by the removal of this strip, a few aerial conidiophores are formed which bear heads of slime spores (Pl. IV, figs. 6, 7). In all essentials these conidiophores agree with those developed below water.

The submerged conidiophores (Text-fig. 6 and Pl. IV, figs. 4, 5) are hyaline and resemble those of *Penicillium*. The ultimate cells of the conidiophore are phialides, of which there may be ten to forty. Conidia (phialospores) are produced from each phialide in basipetal succession and are liberated into the water as soon as they are mature. The conidia (Text-fig. 7) are 45–55 μ long, 2–3 μ wide and each is curved or, more usually, slightly sigmoid. The hyaline spore may be aseptate or divided by a single cross-wall into two, more or less equal cells. At the moment of its liberation the spore is usually uni-cellular and, if a cross-wall appears, it is usually formed after liberation but before germination.

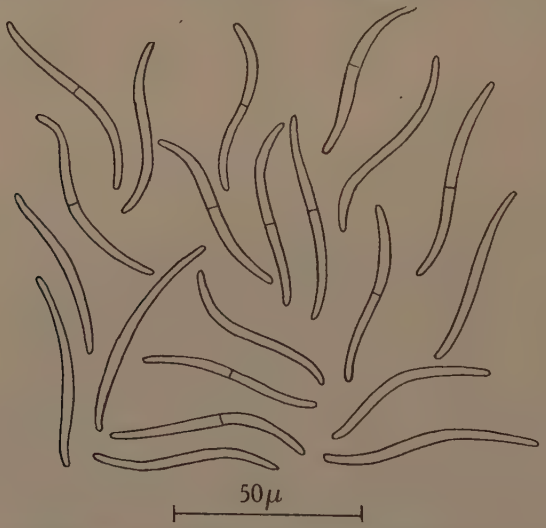
The systematic position of the fungus is uncertain. The very striking form of the conidiophore naturally suggests a place among the genera which have long spores borne on a hyaline, *Penicillium*-like conidiophore. Of such genera, the only likely one seems to be *Cylindrocladium*, with several species, though none of them aquatic. This genus has the advantage that the two-celled spores form a slime-clump at the end of the conidiophore. On the other hand, the spores of all the known species of *Cylindrocladium* are straight, not curved or sigmoid, whereas those of *Flagellospora penicillioides* are filamentous phialospores curved in more than one plane, and very like those of *F. curvula* (Ingold, 1942). In *F. curvula*, the conidiophore usually branches to form a group of phialides with practically no straight, unbranched stalk, and, moreover, the spores are longer (90–150 μ against 40–60 μ), and thinner (1·5 μ against 2·5 μ) than those of *F. penicillioides*. Both species occupy the same ecological niche, as submerged aquatic fungi growing on decaying leaves, but it is doubtful how far this may be stressed. If the fungus now under discussion is to be placed in any established genus of aquatic Hyphomycetes, on the basis of its spore characters, then *Flagellospora* is the only possible genus, and to that the fungus is here referred as a new species. On the other hand, if the form of the conidiophore is regarded as of greater systematic significance than that of the spore, then the three fungi, *Margaritispora aquatica*, *Lemonniera aquatica* and *Flagellospora penicillioides*, would come together in one group. It is of interest to note that colonies of these three species, when grown on agar, all produce from the older parts of the colony, chains of inflated, chlamydospore-like cells. If an attempt were made to construct an old-fashioned phylogenetic tree, then *Margaritispora aquatica* would be an excellent central type giving rise along one line to *Lemonniera aquatica*, and along another to *Flagellospora penicillioides*.

Text-fig. 6. *Flagellospora penicillioides*. Submerged conidiophores from pure culture.

Flagellospora penicillioides n.sp.

Submerged aquatic fungus with branched, septate mycelium. Mycelium on malt agar hyaline at first, later bright brown with moniliform chains of inflated, oil-containing brown cells (chlamydospores), 15–35 μ long, 8–16 μ broad, occurring in the older parts of the aerial mycelium. Aquatic conidiophores hyaline, branched as in *Penicillium*; unbranched stalk part 150–300 μ long, 2·5 μ broad; apical phialides 8–40, 15–25 μ long, 2·5 μ broad. Conidia (phialospores) hyaline, 45–55 μ long, 2·5 μ broad, in the middle but tapering to 1·5 μ at the ends, unicellular or uniseptate, curved or more usually slightly sigmoid, produced in basipetal succession from the phialides. Aerial conidiophores, produced sparingly on malt agar, resemble the aquatic conidiophores but produce heads of slimy conidia.

On a submerged decaying leaf from a stream near Reading, England.



Text-fig. 7. *Flagellospora penicillioides*. Submerged conidia from pure culture.

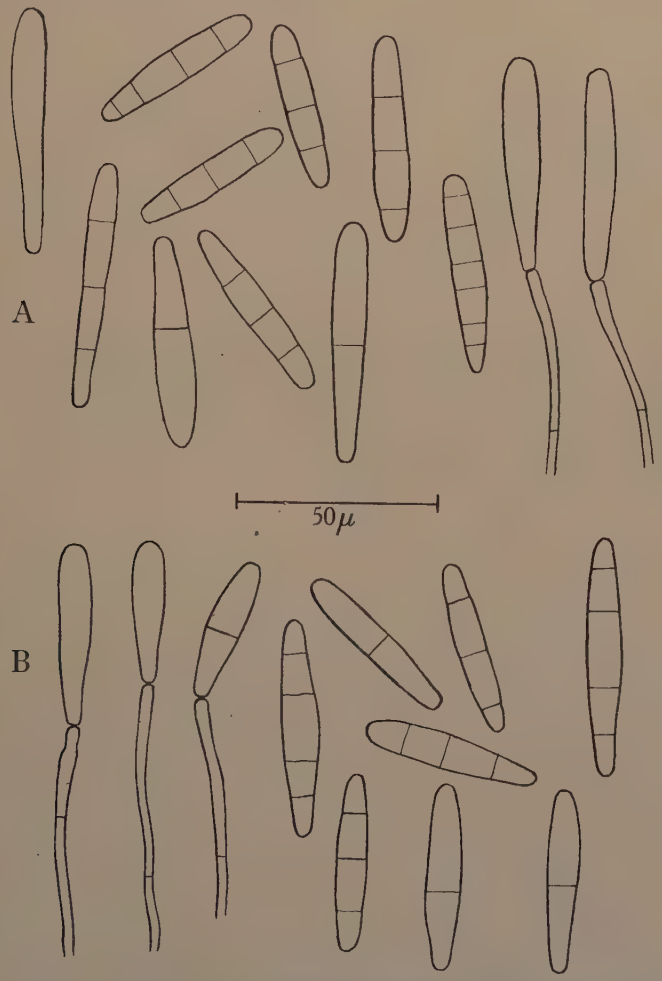
Flagellospora penicillioides sp.nov.

Fungus aquaticus submersus, mycelio repente septato, ramoso. Mycelium in agaro ('malt agar') primo hyalinum, postea brunneum, catenulis moniliformibus cellularum (chlamydosporarum) brunnearum, inflatarum, guttulis oleariis praeditarum, 15–35 μ longarum, 8–16 μ latarum, in partibus vetustioribus aerii mycelii repertarum. Conidiophora aquatica hyalina, ut in genere *Penicillio* ramosa; stipes 150–300 μ longus, 2·5 μ latus; phialides apicales 8–40, 15–25 μ longae, 2·5 μ latae. Conidia (phialosporae) hyalina, 45–55 μ longa, medio 2·5 μ lata utrinque ad 1·5 μ attenuata, continua vel uniseptata, curvata vel plerumque leviter sigmoidea, ex eadem phialide deinceps evoluta. Conidiophora aeria in agaro ('malt agar') parce evoluta, conidiophoris aquaticis similes sed capita conidiorum viscidorum gerentes.

Hab. in folio putrescente in flumine jacente prope Reading, Anglia.

Piricularia submersa n.sp.

Piricularia submersa (Text-fig. 8 and Pl. IV, figs. 1–3) was found on submerged decaying leaves of oak from Anglesey. Later it was found on similar leaves from small streams in Swithland Wood in Leicestershire and from Portaferry in Northern Ireland.



Text-fig. 8. *Piricularia submersa* n.sp. A, conidiophores and conidia from pure culture. B, conidiophores and conidia from submerged decaying oak leaves. The attached conidia are all mature and are beginning to separate from their conidiophores.

The mycelium grows in the leaf-tissue and the simple, hyaline, conidiophores project into the water. The single terminal conidium is of the aleuriospore type. It is straight, elongated (35–65 μ long, 6–9 μ broad), hyaline with an abundant reserve of glycogen giving it a pearly appearance. At the moment when it is liberated the spore is either aseptate or one-septate, but, after liberation and before germination, septation increases.

After the first spore has been liberated a new one is frequently produced as in *Piricularia aquatica* (Ingold, 1943).

The conidium germinates readily in water by a germ-tube from each end.

The fungus was isolated in pure culture on malt agar. The colony is compact with a dense low growth of velvety greenish-grey aerial mycelium. It differs from the colony of *Piricularia aquatica* in the absence of the intense yellow pigment which is produced in the medium by that species. In *P. aquatica* aerial conidia are sparingly produced in freshly isolated cultures, but in *P. submersa* all the colonies observed have failed to sporulate on agar. When, however, a strip of the sterile colony is submerged in water, spore formation, agreeing exactly with that on the leaves, occurs in twenty-four hours (Text-fig. 8).

Although *P. aquatica* and *P. submersa* are regarded as co-generic, there seem to be good reasons for removing both into a new genus; for the time being, however, the two species may be left in *Piricularia*, until the discovery of related species clarifies the position.

Piricularia submersa n.sp.

Submerged aquatic fungus with branched septate mycelium, hyaline at first, greenish grey later. Conidiophores 30–70 μ long, 2–3 μ broad. Aquatic conidia (aleuriospores) hyaline, solitary, terminal, straight, 35–65 μ long, 6–9 μ broad, usually broader in the middle and narrower at the ends, usually 0-septate or 1-septate when liberated but becoming 3–6-septate later, containing abundant glycogen; first-formed conidium truly apical, subsequent conidia produced in succession from near the same point. No aerial conidia produced in culture on malt agar.

On decaying leaves of oak from streams in Leicestershire and Anglesey in Britain, and Co. Down in Ireland.

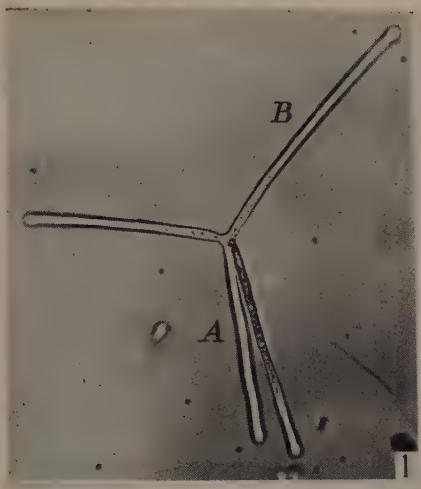
Piricularia submersa sp.nov.

Fungus aquaticus submersus, mycelio repente septato, ramoso, primo hyalino, postea aerugineo-griseo. Conidiophora 30–70 μ longa, 2–3 μ lata. Conidia aquatica (aleuriosporae) hyalina, solitaria, acrogena, recta, 35–65 μ longa, 6–9 μ lata, plerumque in media parte latiora, utrinque angustiora, primo 0-septata vel 1-septata, demum post liberationem 3–6-septata, abundante glycogene; conidium primo evolutum vero apicale; conidia succedentia prope eundem locum deinceps evoluta. Conidia aeria in agaro ('malt agar') haud evoluta.

Hab. in foliis putrescentibus *Quercus* sp. in fluminibus jacentibus in Leicestershire et Anglesey, Britannia, et Co. Down, Hibernia.

Note on the occurrence of aquatic Hyphomycetes in Britain

I have examined samples of submerged decaying leaves from many parts of Britain, and certain generalizations seem justifiable. Most of the species described in previous papers (Ingold, 1942, 1943) are very common and probably occur freely in all running brooks where aeration is good. They occur on all sorts of submerged decaying leaves of broad-leaved trees and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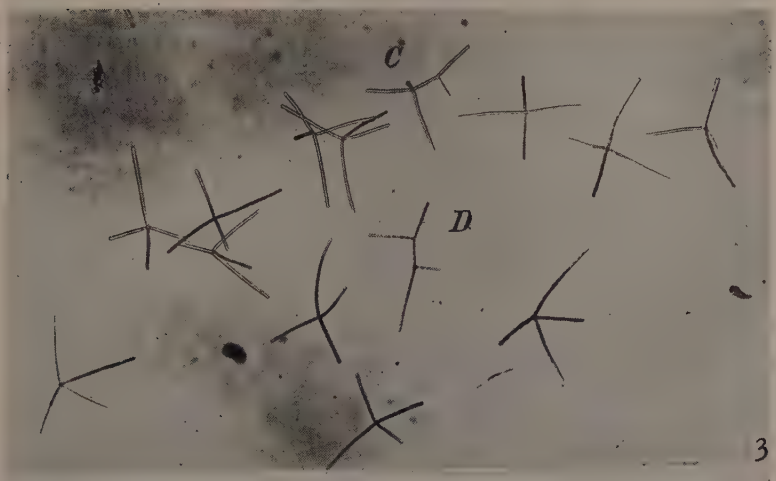
2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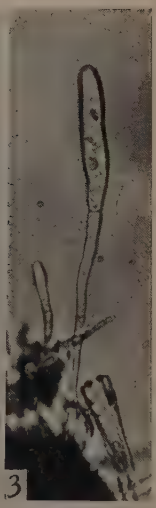
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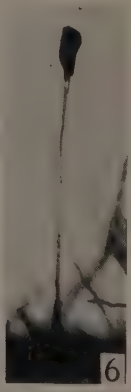
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shrubs (e.g. alder, oak, willow, elm, hazel, hawthorn, chestnut, horse-chestnut, holly, ash, sycamore, ivy, etc.). These fungi appear to constitute the normal fungus flora of submerged decaying leaves in well-aerated water and are particularly abundant when the leaves have almost become leaf-skeletons. They occur throughout the year, although certain species (especially *Lunulospora curvula*) are distinctly seasonal. Most species reach their richest development in autumn and winter. A particular decaying leaf usually has a number of species, often as many as ten, growing on it. These fungi are very easy to recognize, having constant morphological features. The species seem to be remarkably 'good', in striking contrast to certain other aquatic fungi (e.g. Saprolegniales).

My thanks are again due to Miss E. M. Wakefield for her kind help with the Latin diagnoses.

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EXPLANATION OF PLATES

Plate III. *Articulospora inflata* n.sp.

Fig. 1. Conidium from pure culture. *A* is the first-formed arm and *B* the second. The third and fourth arms cannot be distinguished from each other. × 300.

Fig. 2. Conidiophore with a conidium which is just beginning to separate at the point shown by the arrow. The fourth arm of the conidium, pointing directly at the observer, is completely out of focus. × 280.

Fig. 3. Conidia from pure culture. *C* and *D* are abnormal spores of the type shown in Text-fig. 3 E. × 87.

Fig. 4. Conidiophore from oak leaf. The arrow indicates the junction of the conidium and the conidiophore. × 280.

Fig. 5. Branched conidiophore. Arrows show the junctions of the conidia and the conidiophores. × 180.

Plate IV

Fig. 1. *Piricularia submersa* n.sp. Six liberated spores. × 405.

Figs. 2, 3. *Piricularia submersa*. Two conidiophores each with a mature conidium which is beginning to separate. From oak leaves. × 405.

Figs. 4, 5. *Flagellospora penicillioides* n.sp. Aquatic conidiophores from pure culture. Fig. 4 × 372, Fig. 5 × 96.

Figs. 6, 7. *Flagellospora penicillioides*. Aerial conidiophores photographed projecting into the air with their heads of slime-spores undisturbed. × 128.

(*Accepted for publication* 20 *June* 1943)

NOTE: *SCHROETERIA DELASTRINA* (TUL.) WINT. ON *VERONICA ARVENSIS* IN OXFORDSHIRE

By L. E. HAWKER, *Department of Mycology and Plant Pathology, Imperial College of Science and Technology, London, S.W.* 7

The capsules of stunted plants of *Veronica arvensis* collected on Peppard Common, Oxfordshire, in May 1943, contained powdery masses of blue-black smut spores. These spores were joined in pairs and agreed in all particulars with the description given by Winter (1884) of *Schroeteria Delastrina* (Tul.) Wint. According to Sampson's (1940) list of British Ustilaginales this fungus has only once been reported for this country, viz. by Plowright (1889) on *Veronica arvensis* near Fakenham, Norfolk. Plowright states that this fungus while 'common in Germany and France' was 'not hitherto recorded in this country'. Later (Plowright, 1896) he states that 'the curious *Ustilago* which some botanists call *Schroeteria Delastrina* in the interior of fruits of *Veronica hederacea*, in which the twin spores form a striking feature, has been added to our flora'. It is not clear whether he actually found this fungus on *Veronica hederacea* as well as on *V. arvensis*.

Thanks are due to Miss E. M. Wakefield who confirmed the identification.

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(*Accepted for publication* 21 *August* 1943)

PHYCOMYCETES OCCURRING IN GREAT BRITAIN
1. *PYTHIUM MAMILLATUM* MEURS

By C. J. HICKMAN

(With 1 Text-figure)

During 1934–5, in collaboration with Dr C. G. C. Chesters, I investigated a root rot of *Viola* caused by a species of *Pythium* (Chesters & Hickman, 1944). Many isolations of the *Pythium* were made from diseased material and *P. mamillatum* Meurs developed twice in cultures from diseased roots. This and the recent report of the occurrence of the fungus on mustard seedlings (Duerden, 1943) are the only records of *P. mamillatum* in Britain. For details of the complete host range of this fungus the reader is referred to the recent monograph of the genus by Middleton (1943).

The strain of *P. mamillatum* from *Viola* formed sporangia abundantly in water culture, particularly from cultures on hemp seed embryos, incubated at room temperature in sterile distilled water. Under these conditions numerous sporangia appeared after a few days. They were terminal, usually on short lateral branches, or intercalary (Fig. 1, *1–8*). When terminal the sporangia were spherical to subspherical, 16·0–25·0 μ in diameter (mostly 20·0–22·0 μ), average 20·3 μ; when intercalary they were subspherical, subglobose or somewhat pyriform, measuring 18·0–44·0 μ in length by 16·0–18·9 μ in breadth, average 25·9 × 18·6 μ. The sporangia germinated readily in sterile Petri's solution or tap water, forming a vesicle at the end of a short, delicate exit tube (Fig. 1, *9–14*). About ten to fifteen reniform zoospores were usually produced. In the resting condition they were spherical to subspherical, 8·0–10·0 μ in diameter; they germinated by a single germ tube.

In Petri dish cultures on maize-extract agar, colonies of *P. mamillatum* consisted of submerged, radially arranged, slightly sinuous main hyphae, bearing lateral branches the ultimate ramifications of which were delicate and irregularly disposed. Hyphal swellings were scantily developed throughout the mycelium. The colonies reached a diameter of 90 mm. in approximately fifty hours at 30° C.; this was the optimum temperature. Aerial mycelium was absent. Oospores appeared after four days. On malt-extract agar, potato-dextrose agar, oat-extract agar and carrot agar, growth was somewhat slower and a white mat of short aerial hyphae was formed. Sexual organs developed after a few days but oospores were observed only on the two last-named media.

The oogonia were terminal or intercalary on lateral hyphae (Fig. 1, *15–23*). The oogonial wall bore a variable number of short, straight, or curved blunt protuberances. Sometimes there was only a single protuberance while at other times the oogonial wall was covered with them.

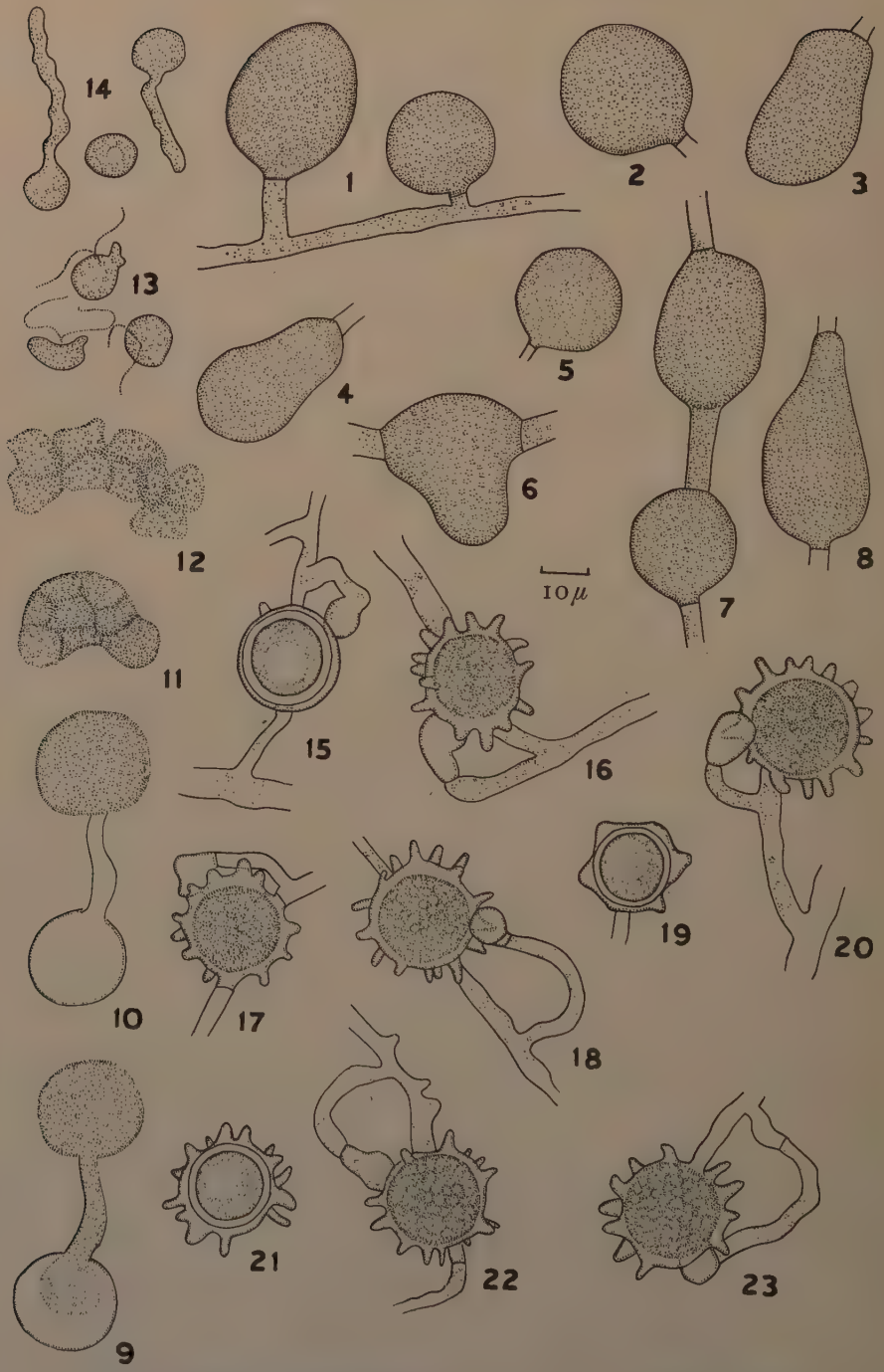

Fig. 1. Asexual (*1–14*) and sexual (*15–23*) reproduction of *Pythium mamillatum*.

Excluding the protuberances the oogonia were 12·0–20·0 μ (mostly 16·0–18·0 μ) in diameter, with an average of 16·8 μ; including the protuberances, 18·0–28·0 μ (mostly 22·0–24·0 μ), averaging 22·9 μ. Each oogonium was provided with a single, usually clavate, androgynous antheridium making apical contact with the oogonial wall and producing there a narrow fertilization tube. The antheridial stalk was sometimes strongly arched. Smooth-walled, spherical oospores completely or almost completely filled the oogonia; they were 12·0–20·0 μ (mostly 16·0–18·0 μ) in diameter, with an average of 16·4 μ, and contained a single reserve globule.

The strain of *P. mamillatum* isolated from *Viola* corresponded closely with the fungus originally obtained from sugar beet seedlings by Meurs (1928). The only point of difference lies in the shape of the sporangia. These, Meurs described as spherical, but I frequently found, in addition, sporangia of irregular shape. The measurements of the two strains are given in Table 1 for comparison.

Table 1

	Measurements in microns by			
	Meurs		Hickman	
	Range	Average	Range	Average
Hyphae, diameter	4·0– 9·3	5·9	2·0– 7·0	3·8
Oogonia, including protuberances	20·3–29·3	24·5	18·0–28·0	22·9
Oogonia, excluding protuberances	13·3–19·3	16·4	12·0–20·0	16·8
Protuberances, length	2·7– 6·0	4·4	2·0– 5·0	3·5
Sporangia (terminal)	14·3–20·7	16·3	16·0–25·0	20·3
Oospores	—	—	12·0–20·0	16·4

The pathogenicity of *P. mamillatum* to *Viola* was tested on a limited scale by placing small pieces of culture of the fungus on oat-extract agar round the roots and collar region of plants growing in pots. As was expected, only slight infection occurred and this was confined to the small lateral roots.

The writer gratefully acknowledges the assistance of Dr C. G. C. Chesters in this work.

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(*Accepted for publication* 10 *September* 1943)

PHYCOMYCETES OCCURRING IN GREAT BRITAIN
2. *PYTHIUM ANANDRUM* DRECHSLER

By C. J. HICKMAN, *Research Officer, Agricultural Research Council, Long Ashton Research Station, Field Laboratory, Evesham*

(With 1 Text-figure)

While making isolations of *Phytophthora Fragariae* (Hickman, 1940) from strawberries received from Scotland in the spring of 1939, a phycomycete possessing spiny oogonia was noticed growing from pieces of root plated on maize-extract agar. A pure culture of the fungus was obtained and an examination of it established its identity as *Pythium anandrum*, recorded originally from rhubarb by Drechsler (1930) and later (1939) shown by him to be pathogenic to water-melon. The pathogenicity of the fungus I isolated towards strawberry roots was not examined; the fungus was considered at the time merely as one of numerous soil fungi inhabiting roots previously invaded by the red core fungus. As this seems to be the first European record of *P. anandrum*, some notes on its characteristic features may not be out of place here.

Asexual reproduction occurred sparingly, this agreeing with Drechsler's isolation. Sporangia appeared only in cultures on hemp seed in sterile distilled water, and then not abundantly. They were very large, irregularly oval or more elongated, non-papillate, papillate, or extended distally in a more or less tubular fashion (Fig. 1, *1–7*). Sporangial proliferation was occasionally seen. One unusually long sporangium (Fig. 1, *6*) showed a transverse septum cutting off a lower portion the contents of which had escaped through a lateral exit tube immediately below the septum; from the latter a short hypha terminating in an oogonium had developed. Instead of germinating by zoospores, certain sporangia produced germ tubes at one or both ends terminating in other, slightly smaller, secondary sporangia (Fig. 1, *4*).

Sexual organs were formed quickly and abundantly in maize-extract agar cultures and on mycelium growing from cultures on this medium in sterile Petri's solution. The oogonia (Fig. 1, *6–8*) were terminal on short, stout lateral branches and bore numerous spines of diverse lengths. Antheridia were absent, the spherical oospores developing parthenogenetically.

In the following table, the dimensions of the sporangia and sexual organs of my isolation are compared with those of the type species. Some measurements from a culture of the latter obtained from the Centraalbureau voor Schimmelcultures are also included. These were made by Mr S. F. Ashby who confirmed the identification of the British fungus.

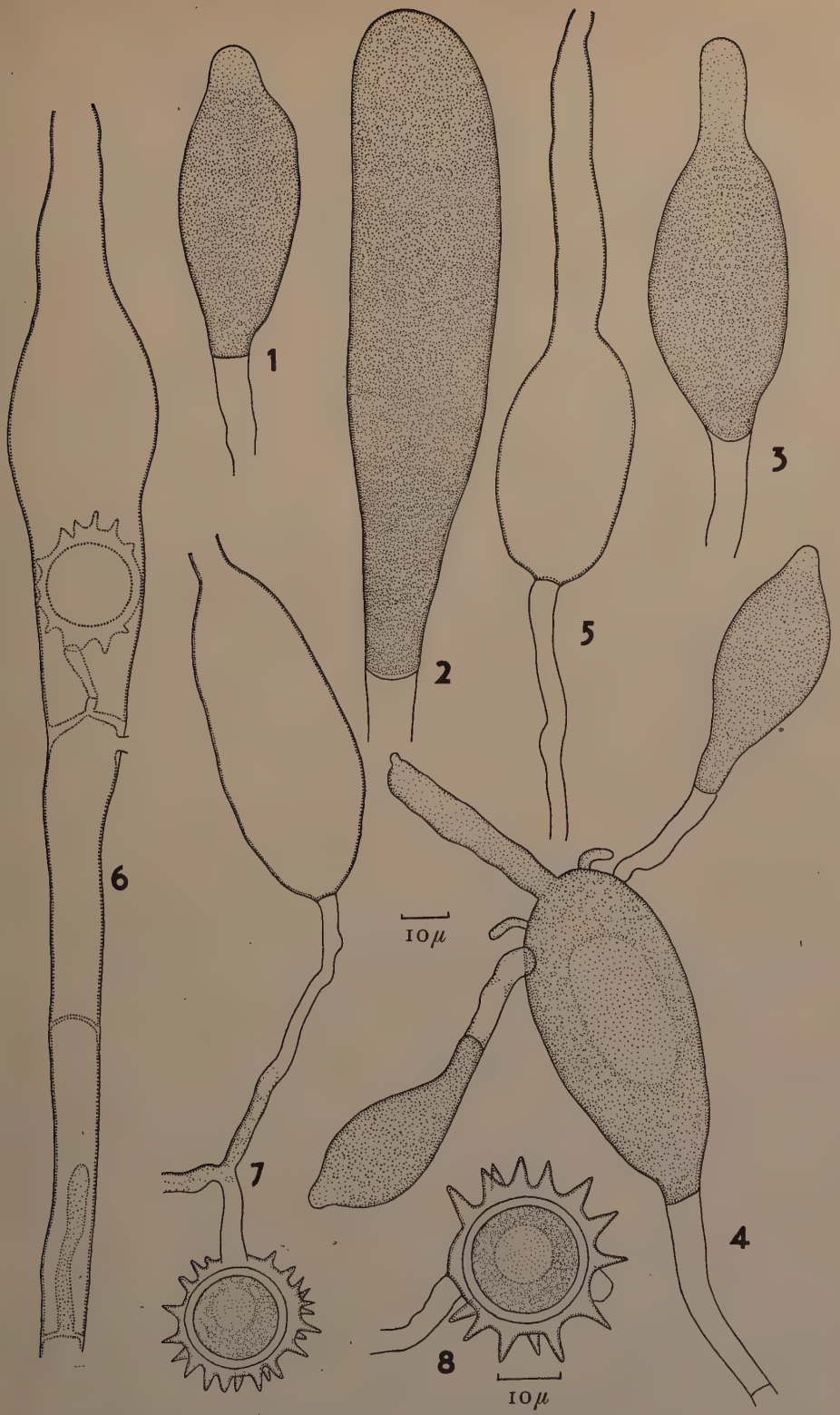

Fig. 1. *Pythium anandrum* Drechsler. *1–7*, illustrating the variation in shape and size of the sporangia; *6–8*, oogonia and oospores.

Pythium anandrum

Measurements in microns of				
Sporangia	Oogonia	Spines	Oospores	
32·0–85·0 × 18·0–40·0 av. 50·4 × 25·3	12·0–33·0 av. 28·3, excluding spines	3·0–11·0 av. 7·1	11·0–28·0 av. 24·4	Drechsler (1930)
52·0–140·0 × 20·0–50·0 av. 91·4 × 39·2	—	—	—	Hickman (1939). Hemp seed in sterile distilled water
	17·0–24·0 av. 20·7, excluding spines	4·0–7·0 av. 5·3	—	Hickman (1939). Maize-extract agar
	28·0–36·0 av. 32·4, including spines	—	—	,,
	26·0–36·0 av. 33·8, including spines	—	14·0–22·0 av. 19·8	Hickman (1939). In sterile Petri's solution from maize-extract agar
37·0–66·0 × 18·0–34·0 av. 48·0 × 25·0	23·0–27·0 av. 25·1	—	19·0–24·0 av. 22·3	Ashby from Hickman
	19·0–31·0 av. 26·3	—	17·0–28·0 av. 23·2	Ashby from C.B.S. culture of Drechsler's isolation

My thanks are due to Mr S. F. Ashby for his ready assistance in the identification of this fungus.

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ON *PYTHIUM VIOLAE* N.SP. AND *P. OLIGANDRUM* DRECHSLER FROM CULTIVATED *VIOLA*

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(With 3 Text-figures)

From 1932 to 1934 we examined numerous exhibition and bedding varieties of *Viola* and pansy from all parts of Britain suffering from a soft rot of the stem in the collar region or of the root system, and isolated several species of *Pythium* from the diseased tissues. Further isolations of these fungi were made by me (C. G. C.) at intervals during the growing seasons from 1935 to 1938. As the species most frequently isolated could not be referred to any recognized species of *Pythium* after continued study, it is now published as *P. Violae*. *P. oligandrum* was described by Drechsler (1930) from isolations from a discoloured rootlet of *Pisum sativum*. So far as we are aware it has not been recorded for Britain. The fungus which we refer to this species was isolated from diseased stems and roots of exhibition and seedling *Viola*.

An account of the symptoms of stem and root rot in *Viola* has already been published by us (1939), and it is sufficient to mention here that the disease has been known in this country since at least 1890 (Kay, 1890) and is now very prevalent. In Britain the disease complex is due to attacks of species of *Pythium*, *Rhizoctonia Solani* Kühn and *Myrothecium roridum* Tode (Preston, 1936), either alone or in various combinations. Elsewhere other fungi are also concerned, and a review of relevant information and an account of original work are given by Van Eek (1938).

Pythium Violae n.sp.

This species was first isolated by me (C. G. C.) in July 1933 from exhibition varieties of *Viola* and has since been isolated repeatedly from twenty-six named varieties and many hybrid seedlings received from widely separated localities in Britain. Its pathogenicity to *Viola* has been proved by inoculation experiments in pot culture in sterilized soil and potting compost and in garden beds of fresh loam, during the summers of 1934–6 and 1938.

In culture on clear maize-extract agar (Ashby, in Wiltshire, 1930) and oat-extract agar the mycelium consists of intramatrical and extramatrical hyphae, becoming sparingly septate in old cultures: Intramatrical mycelium of radiating, widely separated, axial hyphae 2·0–6·0 μ (usually 3·0–4·0 μ) in diameter, producing alternate branches constricted at their

junction with the main hyphae: Secondary and tertiary branches delicate and sinuous: Curved or straight hyphal swellings frequent.

Sporangia (Fig. 1 L–O and Q–S) infrequent in host tissues and in agar cultures, spherical or subspherical, terminal or intercalary, 14–42 μ (usually 22–30 μ, average 26·2 μ) in diameter (Fig. 2), germinating directly by one, less often by two, germ tubes (Fig. 1 N, O and S).

Oogonia (Fig. 1, A–C, F, G, H–K and P) terminal or intercalary, smooth, spherical or subspherical, 16–34 μ (usually 24–30 μ, average 25·7 μ) in diameter (Fig. 2). Frequently developing on secondary branches. When young, contents dense and dark.

Antheridia short, androgynous (Fig. 1 A, B) but at times diclinous (Fig. 1 C, G and H); very occasionally epi- or hypogeal. When androgynous, each supported on a brief antheridial hypha arising from the oogonial stalk immediately below, or at a short distance from, the oogonium. Androgynous types broadly barrel-shaped or cylindrical, slightly curved and broader than their stalk, usually making contact with the basal hemisphere of the oogonium. Diclinous types cylindrical and seldom curved. In both types only the broad, rounded apex is applied to the oogonium and from it a narrow fertilization tube pierces the oogonial wall. One or two antheridia to each oogonium; as many as eight to an oogonium may occur.

Oospores never fill the oogonial cavity (Fig. 1 E, D and I). They are smooth, spherical, 11–28 μ (mostly 18–24 μ, average 20·6 μ) in diameter (Fig. 2). Occasionally two oospores occupy one oogonial lumen. Reserve globule small, embedded in granular protoplasm, sometimes accompanied by a spherical or reniform, refringent body.

The outstanding characters of the species are the very restricted occurrence of sporangia in host tissue or in culture, the absence of swarm-spore production, the dark oily contents of the very prominent oogonia and the abundant production of oospores.

Swarm-spores have been constantly sought since the first isolation in 1933 but have never been observed from sporangia either in culture, in diseased host tissue, or in artificially inoculated tissue. The sporangia are never numerous and have been observed only occasionally on carrot-extract agar, more frequently on hemp embryos in either tub water or soil extract and most frequently in the aerial mycelium formed on sterile twigs of *Sambucus* partly immersed in sterile distilled water. The sporangia are formed at random over the mycelium and are never aggregated or produced on regularly branched fertile hyphae. They usually germinate readily by a single germ tube in sterile tap water and sterile soil extract when these are well aerated.

The most prominent feature of this species in agar culture—especially on clear maize-extract agar—is the dark, almost black contents of the very large oogonia. These are abundantly produced in from five to seven days at 26° C. on clear maize-extract agar even in an isolation which has been maintained on agar for nine years. They are more abundant and more quickly developed on subcultures from fresh isolations. In such cultures oospores are formed in all but a few oogonia and have a relatively thick wall. The fertility of the oogonia declines with the age of the culture and

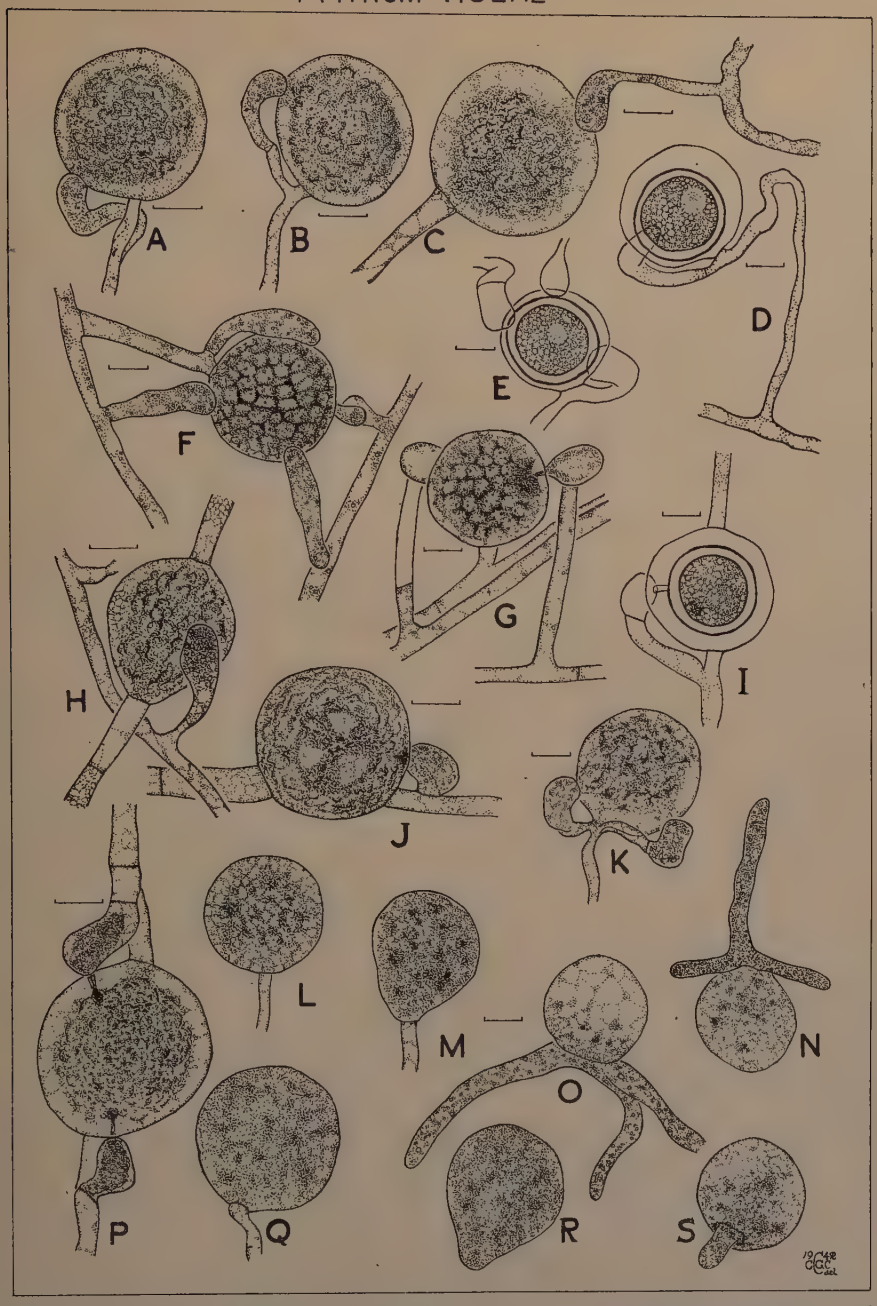

Fig. 1. *Pythium Violae.* A–K and P, oogonia; A and B, with androgynous antheridia; C, with a diclinous antheridium; D, with a single oospore and an empty androgynous antheridium; E, with a single oospore and an empty androgynous and two diclinous antheridia; F, with a single androgynous and three diclinous antheridia; G, with two diclinous antheridia; H, oogonium, intercalary with a diclinous antheridium; I, intercalary oogonium with oospore and androgynous antheridium; J, intercalary oogonium with androgynous antheridium; K, terminal oogonium with two androgynous antheridia; P, intercalary oogonium with two lateral androgynous antheridia. L–O and Q–S, sporangia; L, M and Q, terminal sporangia; O, N, R and S, stages in direct germination of sporangia. Each scale is 10 μ long. Sporangia all drawn to same scale; oogonia to scale indicated for each drawing.

the period over which it is subcultured to agar media, but is restored by culture on sterilized *Viola* stems or by inoculation into the host. As shown in Fig. 2 the usual size of oospores in sterilized *Viola* tissue or inoculated stems and roots is generally smaller than in naturally infected tissues, but isolations from such inoculations yield precisely the same fungus as naturally infected tissues.

This species has points in common with *Pythium pulchrum* von Minden and *P. paroecandrum* Drechsler (as suggested by Mr S. F. Ashby, in litt.) and has oogonia and oospores corresponding in measurement to those of the latter species. It possesses appreciably smaller oogonia than the former species, however, and differs from both in failing to produce swarm-spores which are readily and promptly formed by the latter species (Drechsler, 1930). Our species, therefore, falls within the group which, including *P. ultimum* Trow, is characterized by the direct germination of the sporangium by a hypha and the absence of swarm-spore formation. It has larger oogonia and oospores than *P. ultimum* (oospores, 14–18 μ diameter) and the antheridia seldom show the characteristic pipe-bowl curvature of *P. ultimum*. Among species of this group known to us, our fungus is most closely related to *P. splendens* Braun. Braun (1925) gives the following measurements for the diameters of the 'conidia',* oogonia and oospores of his species: 21·7–48·9 μ (average 36·2 μ), 25·5–34·7 μ (average 31·7 μ) and 21·3–34·7 μ (average 26·6 μ) respectively. *P. Violae* differs from this species in several essentials. The sporangia of our species are rare, never aggregated or produced in clusters from fertile hyphae, and smaller than the so-called conidia of *P. splendens*. They germinate by one or two germ tubes, in contrast to *P. splendens* in which as many as six may occur. The oogonia of *P. Violae* are extremely numerous, not rare as in *P. splendens*, and the oospores are smaller than those of the latter. Further, the optimum temperature of our species, 20–25° C., is lower than that of *P. splendens*, which is given as about 30° C. We therefore consider our species related to, but distinct from, *P. splendens*.

Van Eek (1938) figures and briefly comments on two species of *Pythium* isolated from *Viola*. Species A has no sporangia or oospores but develops so-called 'conidia' which are 16–38 μ (average 26 μ) in diameter; species B has oogonia 15–38 μ (average 25–31 μ) in diameter, one oospore in each oogonium 13–32 μ in diameter, and one or two antheridia 6–9 μ wide by 10–17 μ long to each oogonium. Neither sporangia nor 'conidia' were observed. The species are not fully described but both show some similarity to our fungus. The 'conidia' of species A correspond with the sporangia of *P. Violae* (Fig. 2), but oogonia are lacking. The oogonia and antheridia of species B correspond well with those of our fungus and the fact that 'conidia' were never found on the media used increases the probability that this author had isolated our *Pythium*. In passing it is of note that Van Eek found species A and B pathogenic to *Viola* but not among the first rank of phycomycete pathogens of *Viola* in Holland.

Since our species cannot be precisely referred to a species known to us we publish it under the name *P. Violae* with the following diagnosis.

* The inverted commas are inserted by me (C. G. C.).

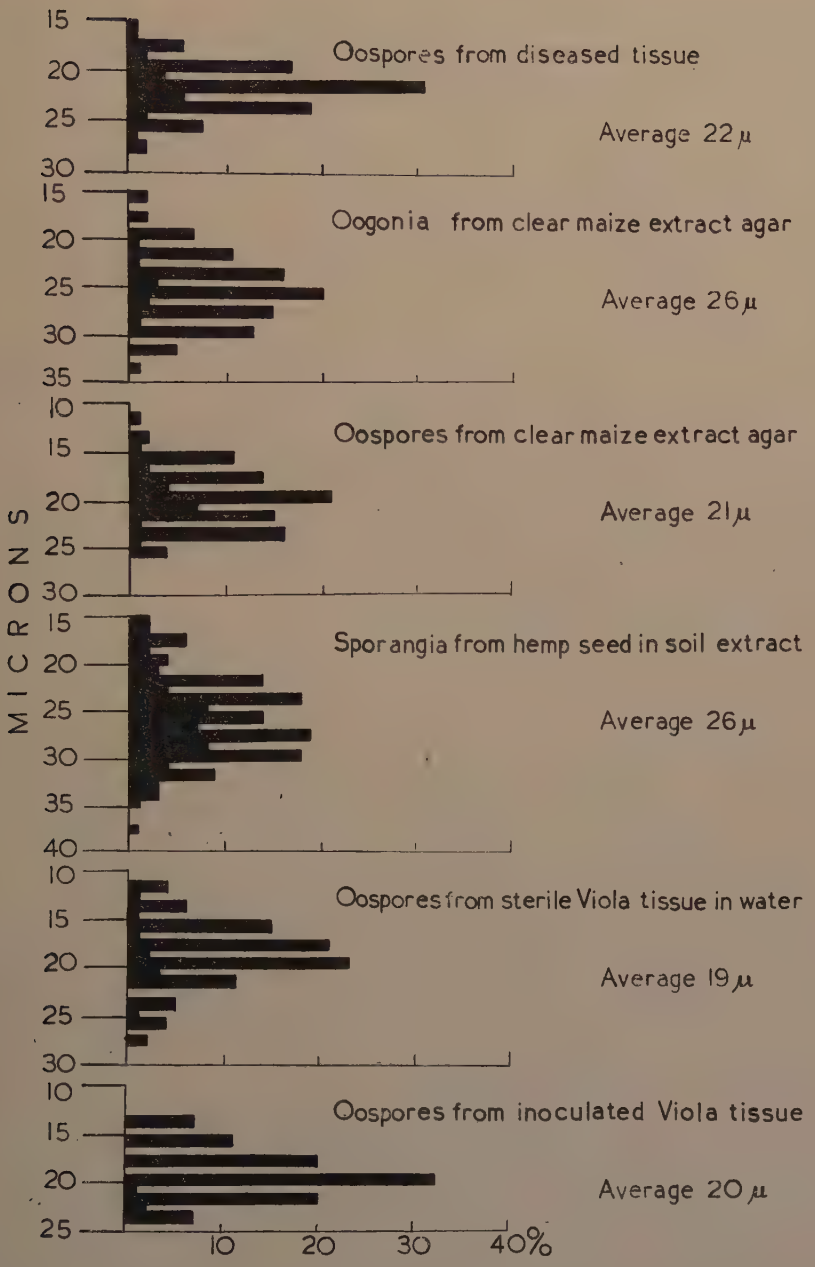
MICRONS
Oospores from diseased tissue
Average 22 μ
Oogonia from clear maize extract agar
Average 26 μ
Oospores from clear maize extract agar
Average 21 μ
Sporangia from hemp seed in soil extract
Average 26 μ
Oospores from sterile Viola tissue in water
Average 19 μ
Oospores from inoculated Viola tissue
Average 20 μ
10
20
30
40%

Fig. 2

Pythium Violae sp.nov.

Mycelium ex hyphis radiantibus conflatum, hyphis 2–6 μ diam., primitus eseptatis, postero parce septatis, ramulis terminalibus gracillimis interdum hic illic tumide inflatis curvatisque. Sporangia rara, sphaerica v. subsphaerica, terminalia aut intercalaria, 14–42 μ (plerumque 22–30 μ) diam., singulo aut rarius pluribus tubulis germinationis praedita. Oogonia sphaerica v. subsphaerica, terminalia, intercalaria, laevia, 16–34 μ (plerumque 24–30 μ) diam. Antheridia vulgo androgyna, rarius diclina; androgyna e basi oogonii oriunda et tunc leviter curvata, cylindrica aut doliiaria, haud allantoideae; oogonio antheridiis pluribus (1–8, vulgo singulo aut binis) instructo; apices antheridiorum parieti oogonii late adnati tubulo conjugationis tantum angustissimo perforati. Oosporae singulae aut rarissime binae, oogonium non complentes, sphaericae, laeves, 11–28 μ (plerumque 18–24 μ) diam. Ex stipite putrescente, necnon radice, Violae cult. elicitum.

Pythium oligandrum Drechsler

The isolations which we refer to this species were obtained in 1932 and 1934 from diseased roots of *Viola* John Adamson, in 1935 from diseased stems and roots of *Viola* N. B. Wallace and in 1936 from hybrid seedlings showing damping-off. A subculture of the original isolation was sent to Mr S. F. Ashby who expressed the opinion that it: 'Comes nearest to *Pythium oligandrum* Drechsler.' As we have not seen subcultures of Drechsler's isolation a brief description of our isolations and a table of comparative measurements are given.

On clear maize-extract agar the extramatrical mycelium aggregates in small masses of loosely woven hyphae. The intramatrical mycelium consists of primary hyphae 2–6 μ (usually 2–4 μ) in diameter, giving lateral branches ending in tufts of short delicate hyphae. It is sparingly septate when old.

In water culture simple or compound terminal or intercalary sporangia are abundant (Fig. 3 I–M). Terminal sporangia, when simple, either spherical (10–28 μ, mostly 18–24 μ, average 20·8 μ, in diameter) or pyriform, obpyriform or oval (18 μ long by 16 μ wide to 40 μ long by 20 μ wide, average 24·1 μ by 21·1 μ); when compound, consisting of two to five ovoid or highly irregular elements closely connected by cylindrical hyphal segments varying in length but usually short. Intercalary sporangia are formed on a portion of the mycelium clearly enclosed by two septa. On this the sporangia occur singly or in series as subspherical swellings, 14–28 × 16–32 μ (average 22·5 × 23·7 μ), or as sessile irregular lateral lobes.

Oogonia (Fig. 3 A–F) abundant on agar and in host tissues; spherical, intercalary (generally on a short lateral hypha, sometimes on axial hyphae) or less often terminal. The oogonial wall forms numerous, conical, straight (occasionally slightly curved), sharp-pointed spines, up to 3 μ in diameter at the base and 2–6 μ (usually 3–4 μ) long. Diameter of oogonia, including spines, 24–34 μ (usually 26–28 μ, average 24 μ).

Antheridia at times absent, then the oogonium appears to develop parthenogenetically; when present (Fig. 3 A–F) mainly diclinous, arising

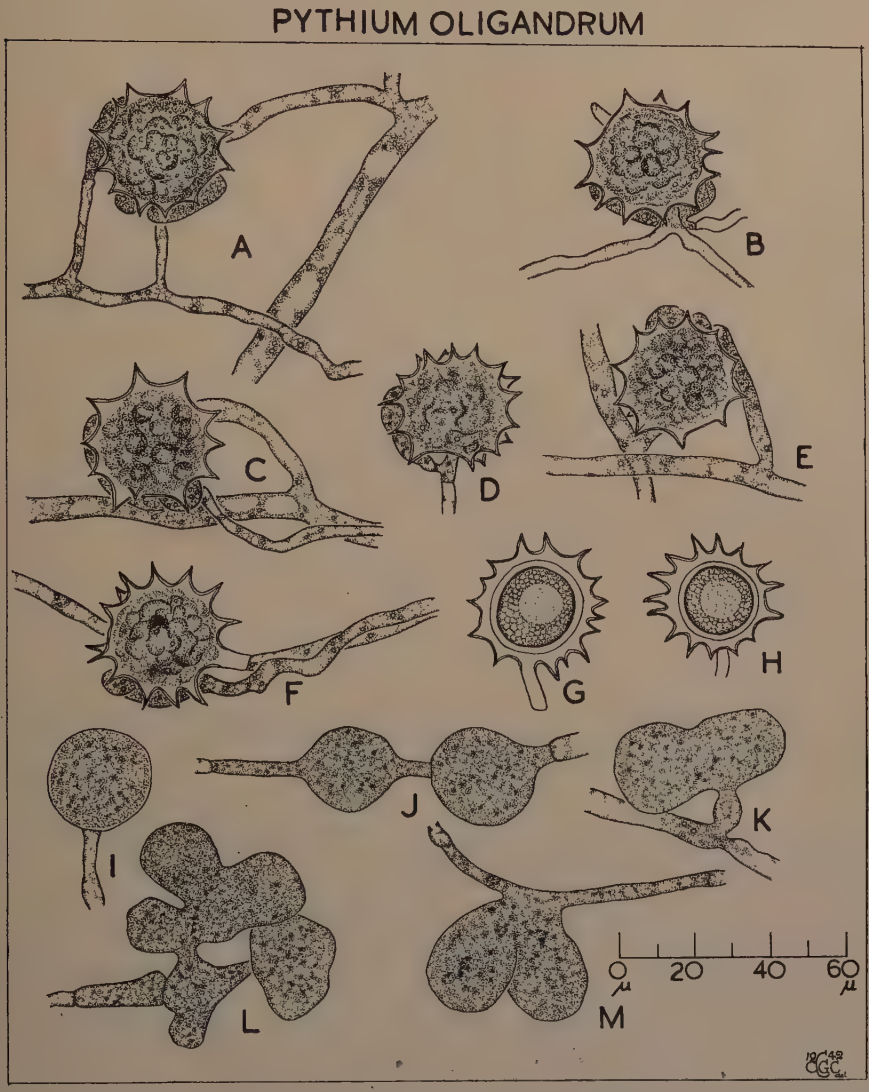

Fig. 3. *Pythium oligandrum.* A–H, oogonia; A, with two diclinous antheridia—one clearly bilobed; B and C, with single, bilobed, diclinous antheridia; D, with an androgynous antheridium; E and F, with simple, diclinous antheridia; G and H, with oospores. I–M, sporangia; I, terminal and spherical; J and M, intercalary; K, lateral; L, compound, terminal. All drawings to the same scale.

from slender antheridial hyphae and themselves slender, simple or bilobed, and closely applied to the oogonial wall over most of their length. Usually one antheridium (never more than two) to each oogonium. Fertilization

tube not observed, but Drechsler describes a short fertilization tube arising from near the apex of the antheridium in his species.

Oospores (Fig. 3 G, H) spherical, smooth, almost filling the oogonial lumen, 17–26 μ (usually 20–22 μ, average 21·3 μ) in diameter. Contents granular, enclosing a single, large, reserve globule. Germinating after a short resting period by a sessile or stalked sporangium.

On clear maize-extract agar the oogonia of our isolations do not often produce oospores. The proportion of oogonia developing oospores increases on carrot agar and is highest on hard oat agar.

The morphology of our fungus corresponds closely with that described by Drechsler for his isolation. While the measurements of the hyphae, sporangia, oogonia and oospores of the isolations from *Viola* are smaller than those given by Drechsler (Table 1) we consider that, as our measurements fall within the range for each organ, our fungus is to be referred to this species.

Table 1

	Measurements in microns			
	Given by Drechsler		From our isolation	
Organs	Range	Average	Range	Average
Subspherical				
Sporangial elements	25·0–45·0		10·0–28·0	
Hyphae	1·5– 6·8		2·0– 6·0	3·9
Oogonia without spines	17·0–35·0	26·4	20·0–30·0	24·0
Spines	3·0– 7·0	3·9	2·0– 6·0	4·0
Oospores	15·0–30·0	23·1	17·0–26·0	21·3

We wish to thank the many members of the National Viola and Pansy Society who provided the material on which our studies were conducted. To the late Sir Edwin J. Butler and to Mr S. F. Ashby we are especially grateful for the loan of papers and for much helpful advice and criticism during the course of this work. To my friend and colleague, the late W. B. Grove, I (C. G. C.) desire to record my most sincere thanks for his assistance and guidance with the diagnosis of *P. Violae*.

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PHYCOMYCETES OCCURRING IN GREAT BRITAIN

3. *PYTHIUM APHANIDERMATUM* (EDSON) FITZPATRICK

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(With 2 Text-figures)

In June 1942, wilted specimens of mature glasshouse cucumber plants were brought to me for examination from Honeybourne, Worcs. The base of the stem of each affected plant was girdled by a dingy yellow lesion extending two to three inches upwards from soil level and bearing on its surface a gummy exudate. A dark green, water-soaked band marked the upper limit of the visibly diseased area. The roots were healthy. A coarse, non-septate mycelium was present in great abundance in the diseased tissues and a fast growing species of *Pythium* was isolated from them without difficulty. Raper's technique (1937) was used as a routine measure to ensure that the culture was free from bacteria.

Morphology

The asexual stage of the fungus was obtained by placing pieces of diseased cucumber stem in sterile distilled water in Petri dishes and leaving overnight at laboratory temperature. Sporangia developed under these conditions are illustrated in Text-fig. 1. They varied from slightly thickened but otherwise undifferentiated hyphal segments of considerable length (Text-fig. 1, *1*) to irregular, sometimes branched, diversely lobulate elements (Text-fig. 2, *2–6*). Lobulate sporangia were also produced on maize-extract agar and in water culture from this medium (Text-fig. 2, *1–6*). In these water cultures, made from diseased tissue and from maize-extract agar cultures, many sporangia were produced and germinated readily in the manner typical of the genus, giving rise to large numbers of zoospores; no other phycomycete that I have examined has yielded its asexual stage in such profusion.

Sexual organs (Text-fig. 2, *7–12*) appeared after five to six days in cultures on maize-extract agar. The spherical oogonia were borne terminally, often on short lateral branches, and were fertilized by one, occasionally two, barrel-shaped, intercalary, or less commonly, terminal antheridia. Sometimes the antheridial hypha could clearly be seen arising from the same hypha as the oogonium; at other times there was no such close relation. Each oogonium gave rise to a single, spherical oospore. On maize-extract agar the oogonia varied from 24 to 32μ in diameter (average 26·5μ), the oospores from 20 to 28μ (average 22·1μ). Sexual organs formed on mycelium growing from maize-extract agar cultures in sterile distilled water gave the following measurements: oogonia 20–30μ (average 24·8μ); oospores 16–24μ (average 20·6μ).

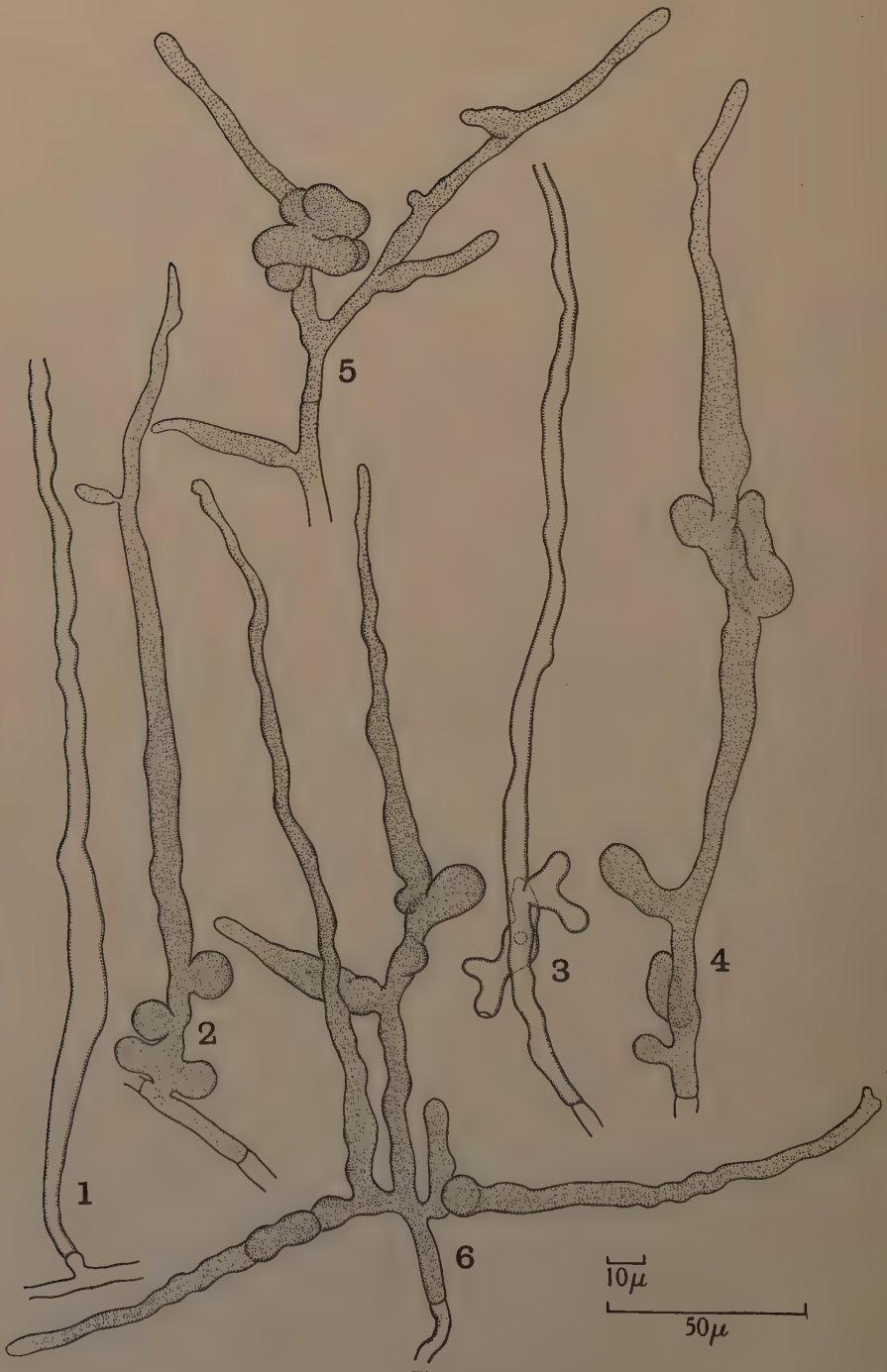

Fig. 1.

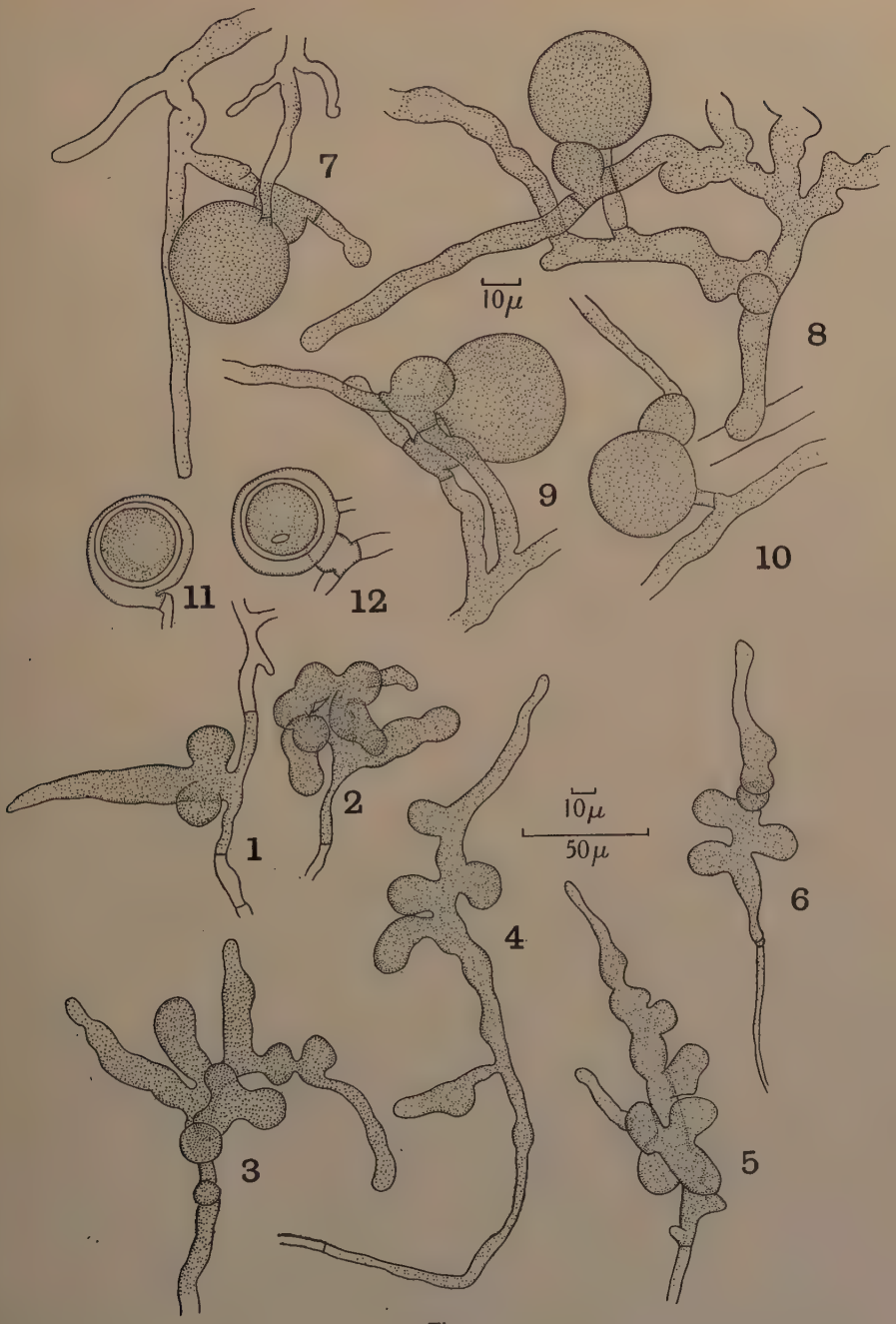

Fig. 2.

Identity

Two species of *Pythium* with characters very similar to those described and figured have been recorded in the literature. One, isolated from sugar-beet seedlings and radishes, was originally named *Rheosporangium aphanidermatus* (Edson, 1915), and formed the type of a new genus of the Saprolegniaceae. On the basis of work by Carpenter (1921), *R. aphanidermatus* was transferred to the genus *Pythium* under the binomial *P. aphanidermatum* by Fitzpatrick (1923). The other species was one of three forms included by Butler (1907) under *P. gracile* Schenk. It was described by Subramaniam (1919) as a separate species, *P. Butleri*, differing from *P. gracile* in not being an algal parasite, a somewhat slender justification for the erection of a new species. It was pathogenic to ginger, tobacco, chillies and papaya. Fitzpatrick (1923) regarded *P. Butleri* as synonymous with *P. aphanidermatum* but retained *P. gracile* as a distinct species.

Most authors have followed Fitzpatrick in his conception of *P. aphanidermatum*. Drechsler, at first of the same opinion (1925), later (1934) separated *P. aphanidermatum* from *P. Butleri* on the basis of small morphological differences and on their reproductive behaviour. 'The generally smaller zoosporangia [of *P. aphanidermatum*] are derived from elements much less extensive, less swollen and less elaborately branched. The zoospores are smaller, their diameter, after encystment, averaging about 9μ instead of 11μ; and their production is difficult to induce on artificial substrata. The sexual structures are smaller, the oogonial diameter averaging about 22·0μ instead of 27·0μ, the oospore diameter about 17·5μ instead of about 22·5μ. The smaller antheridium is much more frequently produced immediately adjacent to an oogonium, though here also an adjacent antheridium generally fertilizes some less directly connected oogonium.' In the most recent contribution to the subject Middleton (1943) considers these differences to be without significance. In support of his conclusion he states that cultures labelled *P. Butleri* were indistinguishable from those labelled *P. aphanidermatum*. As I have examined only one isolation I cannot express an independent opinion but, in view of the capacity for variation exhibited in this group of fungi, I prefer to follow Fitzpatrick and provisionally identify the cucumber fungus as *P. aphanidermatum* (Edson) Fitzpatrick.

Host range

P. aphanidermatum (including *P. Butleri*) has a world-wide distribution on many plants, a detailed list of which is given by Middleton (1943). It appears to be particularly common in semitropical and tropical regions and has frequently been isolated from cucurbitaceous hosts. On cucumber the species has been found in the fruit and in seedlings, but I have been unable to discover any mention of the association of the fungus with a foot rot of mature plants such as I have described.* Drechsler (1925) found the fungus to be the cause of a watery decay of cucumber fruits during transit.

* In an article entitled 'Cucumber plants going off at the surface of the soil' (*Gard. Chron.* xxvii, 1900, p. 274) W. G. Smith describes a similar disease associated with a *Pythium* sp., probably *P. debaryanum*.

The watery type of decay and the luxuriant external development of white mycelium led him to suggest the name 'cottony leak' for the disease. Other investigators have encountered the same disease or have produced it by inoculation with pure cultures (e.g. Yu, 1934; Gottlieb & Butler, 1939). Yu (1934) found *P. aphanidermatum* to be responsible for Damping-off of cucumber seedlings.

Pathogenicity

I had no opportunity to test the pathogenicity of my isolation of *P. aphanidermatum* towards mature cucumber plants, but inoculations were made on seedlings, young plants and fruits. In the warm, moist atmosphere of a cucumber house, seedlings were very rapidly invaded and were killed within twenty-four hours of placing small pieces of an agar culture of the fungus just below soil level, near the stem base. The progress of infection was not influenced by wounding, for unwounded seedlings died as quickly as those injured at the base before inoculation. A parallel series of inoculations on young plants about fifteen inches high gave symptoms more typical of the disease on mature plants while inoculation of fruits resulted in the 'cottony leak' condition. Although no experiments could be carried out with mature plants, the results of the inoculations of young plants and fruits strongly suggest that *P. aphanidermatum* was the primary cause of the disease seen at Honeybourne. Moreover, when the wilting plants were given a heavy watering with a solution of a proprietary fungicide containing a copper ammonium compound the disease was checked and the plants recovered.

I am indebted to W. C. Moore for drawing my attention to W. G. Smith's record.

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NOTE ON THE HABIT AND SPORE FORMATION IN A *SAPROLEGNIA*

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(With 1 Text-figure)

Among the catches of water fungi made for teaching purposes in January 1943 one fungus appeared on the remains of a tortoiseshell butterfly immersed in pond water obtained from the Chelsea Physic Garden, which when cultured on boiled cress showed a deceptive resemblance to *Allomyces*, for it had a tree-like habit (Fig. 1 A, B) with a stout basal 'trunk' hypha on which grew smaller branches bearing spheroidal reproductive bodies often in chains either terminally or laterally. The absence of pseudosepta and the disproportionately long trunk were against an attribution to *Allomyces*. Subsequent examination of young growths on various media revealed typical saprolegniaceous sporangia, and, after four months in culture, oogonia and antheridia appeared. These suggested a position for the fungus close to *Saprolegnia diclina* Humphrey, but the stout basal trunk did not agree with Coker's (1923) statement that *S. diclina* has little branched hyphae of moderate size. Coker described *S. anisospora* as having 'main' hyphae from 40 μ in diameter below to 11 μ or even less near the tip, but he does not emphasize the occurrence of the tree-like habit in *Saprolegnia*. That feature in the material now described, together with a number of observations which emphasize the plasticity of the gemmae and of their contents, appear worthy of record.

Further experience with the *Saprolegnia* showed that, though typical sporangia were formed on very young growths, there was a tendency, progressive with advancing age, for the formation of gemmae, and that when the colony was a few days old it was difficult to find any other type of reproductive body; this explains why typical sporangia were not seen in early cultures which were not looked at until growth was obvious to the naked eye. Study of cultures of intermediate age (Fig. 1 C) resulted in the discovery of typical sporangia showing proliferation, typical sporangia formed in basipetal succession, typical sporangia in terminal positions with spheroidal gemmae below, clavate gemmae borne terminally with or without cylindrical gemmae below or with ovate gemmae below, and terminal spheroidal gemmae either solitary or with others below in chains. There were also typical sporangia borne terminally with others arising just below the septum, these sometimes repeating basipetally; typical terminal sporangia with gemmae sometimes in basipetal chains, arising as branches from below the septum. Moreover, gemmae might occupy the terminal position with sporangia below them. These intergradations of shape and position, as well as the knowledge that all these types of reproductive organ may finally liberate zoospores, made it inevitable to think of them all as zoosporangia. Typical zoosporangia were formed so sparingly that it would

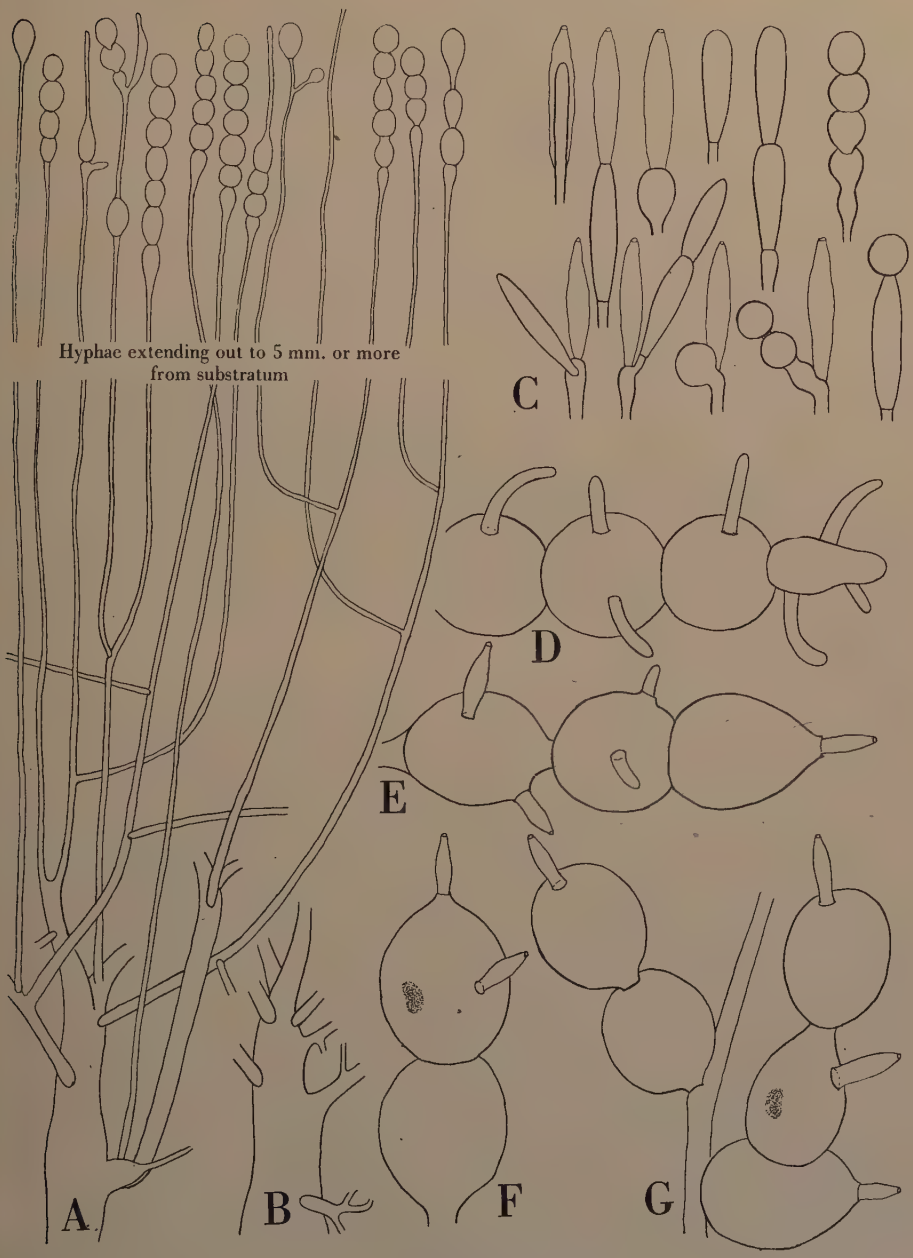

Fig. 1. For explanation see text.

seem that gemmae are the characteristic reproductive bodies of this fungus, and thus that this *Saprolegnia* in its processes of asexual reproduction has reached an evolutionary level comparable with that of *Cystopus* with the 'sporangia' formed in chains and showing delay in the liberation of their zoospores. Such conceptions are not new: according to Coker, Maurizio noted gradations between typical sporangia and gemmae (his 'conidia') in *Saprolegnia rhaetica*, but recent authors have paid little heed to them. As so many forms of reproductive body are present simultaneously in one colony it must be some very minor circumstance which controls their shape and possibly also the period which elapses before they liberate their zoospores.

Experiments on the conditions necessary for the liberation of zoospores from gemmae were not conclusive, but it was clearly shown that peptone stimulated the gemmae to sprout new hyphae (Fig. 1 D). During the early stages of this sprouting the gemmae bore a close resemblance to gemmae with papillae (Fig. 1 E) formed when zoospores are about to escape in cultures grown in pond water, but it can only be surmised that peptone or some other comparable substance is a prerequisite to zoospore emergence under natural conditions. Gemmae which had formed short sprouts as a result of treatment with peptone often liberated zoospores readily if transferred to glucose solution. It is well known that change of conditions favours zoospore formation, and it may be that gemmae of this *Saprolegnia* require a suitable intensity of nitrogenous stimulation followed by a suitable stimulation by carbohydrates.

Many zoospores were seen in motion and later settling down to round off, their erratic progress changing to movement in circles of shorter and shorter radius till movement ceased. Only a few seconds separated the beginning of gyration from final quiescence. Early in the course of these observations all zoospores seen swimming were coffee-bean shaped, and they were assumed to be second-phase zoospores which had escaped from cysts. Later, however, bean-shaped zoospores were seen motile within four different sporangia which did not contain any empty cyst walls (Fig. 1 F, G). These zoospores must have re-entered the gemmae or else have been formed inside as bean-shaped spores. This latter is not so improbable as it might seem, for observations showed that zoospores do not always have the same form when they are set free. Very often they were typical, pip-shaped, and tapering to the anterior end. In other instances although they attained this shape after a period of motility they escaped as sausage-shaped bodies. Still other zoospores were observed which retained the sausage shape until they encysted, and some of these were so bent as to be almost bean shaped. Elongated zoospores are not unknown in the Saprolegniaceae; all the spores of *Aphanomyces* and *Leptolegnia* and the large spores of *Saprolegnia anisospora* are said to have this shape on emergence. In *S. anisospora* they are sometimes bent and become pip-shaped only after swimming for a time. In *Leptolegnia* the pip shape is said to result from the bending of a straight elongated cell, the free ends of the bent sausage approaching and coalescing to form the tail of the pip. In *Aphanomyces* no change in shape seems to occur before the zoospores encyst at the mouth of the sporangium. Yet the

zoospores of all three resume motility as bean-shaped zoospores. Published figures suggest that in *Leptolegnia*, when pip-shaped zoospores are forming, the groove between the free ends of the bent sausage disappears, but before it does so the groove might well be compared with the furrow in the bean-shaped zoospore which appears when the cyst bursts. These examples show that the shape of the zoospore is not absolutely stereotyped, and it may be that inside the gemmae, which were seen to contain bean-shaped zoospores, conditions were sufficiently similar to those normally present in cysts to induce the change in shape. However this may be, it is interesting to find yet another example of features characteristic of one genus of the Saprolegniaceae occurring in a species of another genus.

Activity of the zoospores affords another example of this phenomenon. Gemmae were observed to have a marked tendency to produce abnormal zoospores, and the more the zoospore differed from the pip shape, the more sluggish were its movements. Such sluggishness is regarded as characteristic of *Saprolegnia asterophora* and is recorded for *S. curvata* and indicated for *Isoachlya* by Coker. In a growth on oatmeal agar of the *Saprolegnia* described here, numerous aerial hyphae formed gemmae which fragmented into portions each about the size of large zoospores, which under these conditions of relative dryness would seem to have lost their motility entirely.

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A *CYLINDROCLADIUM* AS THE CAUSE OF A SHOOT WILT OF VARIETIES OF PLUM AND CHERRY USED FOR ROOTSTOCKS

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(With Plates V–VIII and 3 Text-figures)

Certain varieties of plum and cherry are propagated vegetatively, by stooling and layering, to provide rootstocks for other varieties. The bases of the young shoots that arise from the stools or layers are covered with soil to induce rooting, and in autumn or winter the rooted shoots are removed for planting out so that later they can be worked (grafted or budded) with scion varieties. An account of field observations on a wilt disease of such shoots has recently been published (Wormald, 1943); the present paper

describes the fungus in more detail and gives results of inoculation experiments.

The earthing, with which the disease is intimately connected, is not one complete operation; it is carried out at several periods during the growing season, and the procedure now generally adopted is this:

Operation	Time of year
Layers pegged down	February and March
Layers covered with about an inch of soil	Soon after the layers are pegged down, or early March, i.e. before the buds burst
Light earthing	As the shoots appear in April
First heavy earthing	End of May or beginning of June
Second heavy earthing	End of June or early July
Sometimes a third rather heavy earthing	Mid-July
Layers uncovered and the shoots removed	November and December

Symptoms of the disease may be seen in June, but they become more noticeable during July and August. In an experiment described below flagging of the leaves on infected shoots was first seen on the eighteenth day after inoculation, and most of the wilting occurred within the next two weeks; that is, it was most conspicuous in four to five weeks after inoculation. Comparing these results with observations in the field, and assuming that infection starts soon after the shoots are earthed-up, it appears that the wilting in the field occurs chiefly as a result of the heavy earthing given at the end of May or beginning of June, though the second heavy earthing is probably responsible for some of the later wilting.

Earthing is carried out when the soil is moist and cohesive, for the operation is easier then than when the soil is dry and friable. It is started when the shoots are only a few inches high; the lower leaves thus become covered with moist soil and soon rot away. If however there are parasitic fungi in the soil these may attack the leaves and extend into the shoots to cause wilting. On the underground (earthed up) parts of the affected shoots are lesions several centimetres long and these cause the leaves to flag and finally wither. In the early observations on such wilting *Monilia cinerea* was isolated from affected shoots and in inoculation experiments was found to cause a disease similar to that seen in the field (Wormald, 1935). In recent years, however, *M. cinerea* has never been isolated from the wilted shoots; usually the lesions bear numerous microsclerotia, and the fungus isolated from affected tissues, or obtained from the sclerotia, is quite different from *M. cinerea*. The frequency with which it has been isolated, first in 1932 and then in subsequent years, suggests that it is now the chief cause of the wilting, and experiments described below confirm that it is parasitic.*

Strains of the fungus isolated from shoot lesions and grown in pure culture on various media all produced microsclerotia but no fructifications. Infected shoots were placed in moist chambers in attempts to induce the fungus to fruit, but without success. Certain fungal fructifications did appear under these conditions, particularly those of *Gliocladium roseum*

* In 1942 *Botrytis cinerea* was isolated from a wilted layer plum shoot, so there is the possibility that this fungus too may under certain conditions cause a similar disease.

Bainier, but when this fungus was grown in pure culture its habit proved to be quite different from that of the fungus isolated direct from the lesions; it sometimes appeared also as a contaminant in plates prepared direct from affected tissues, and seems to be frequently associated with the parasite.

Thus for some years the shoot wilt fungus was not identified. In June, 1936, however, a white mould was found on lesions of shoots of a layered apricot variety. This mould bore branched conidiophores each with a cluster of cylindrical two-celled conidia which, when isolated on agar plates, gave rise to cultures similar to those of strains obtained previously from the tissues of lesions. Since that time a few similar fructifications have been found on other shoots taken from the open field, but only on one cherry and two plum shoots, although very many wilted shoots have been examined.

In 1940 more fructifications of the same kind were found, but under different conditions. Soft-wood cuttings of Pershore plum had been placed in a frame containing sand and peat to induce rooting. Various fungi appeared on some of these cuttings. The one occurring most frequently produced numerous fructifications on the cuttings and on the leaves similar to those found previously on apricot layer shoots. Single-spore isolations were prepared and the resulting cultures were like those obtained from the fungus in wilted shoots. It is assumed, therefore, that all these isolations, from spores and from tissues of lesions, can be referred to one species of fungus.

The fungus has been isolated from (*a*) small pieces of the tissues from lesions on layer shoots of plum, cherry, and peach, (*b*) sclerotia found on such shoots, (*c*) spores found on a wilted layer shoot of apricot, and (*d*) spores on soft-wood plum cuttings and their leaves in a propagating frame. These isolates have been cultured on prune agar, and some of them on various other agar media; all grow out uniformly, forming a circular 'colony', at first hyaline, later golden brown as numerous microsclerotia develop. They are very similar to each other in culture but some show a greater tendency than others to develop the sclerotia in concentric zones; strains showing distinct zoning have less aerial mycelium than the rest.

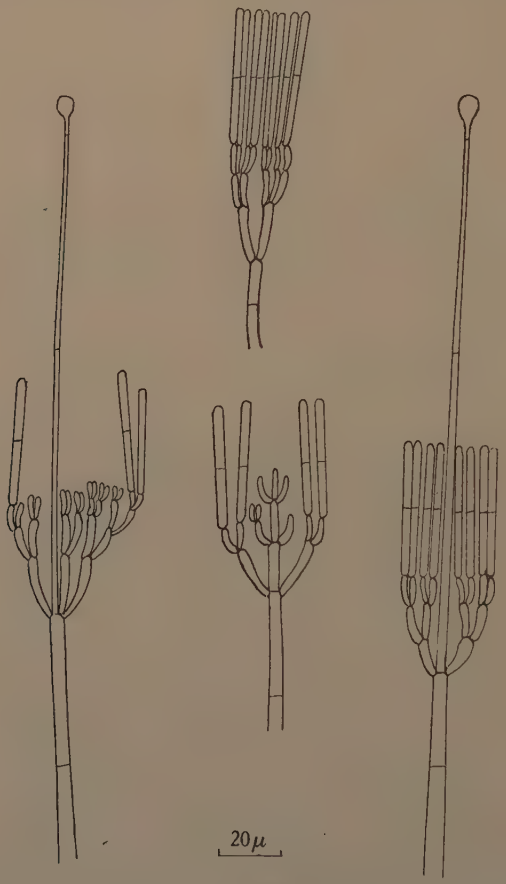
These strains on various agar media have never developed fructifications. One strain, isolated direct from the tissues of a lesion, was grown on plates of the following media in an unsuccessful attempt to induce it to fruit:* 2% plain agar; 0·5, 2·0 and 8% malt agar; 2% cornmeal agar; potato-dextrose agar; 0·01 and 0·1% marmite agar. No spores appeared on any of the plates. The plain agar and the marmite agar gave very thin growth, but the rest yielded good growth with many microsclerotia, except 0·5% malt agar where the sclerotia were relatively few.

Some strains, however, have produced fructifications when inoculated into plum or cherry leaves or green shoots kept in moist chambers. The strains isolated from spores readily fruit under these conditions, but those isolated from tissues of shoot lesions fruit less freely if at all; only one isolate from plum and two from cherry shoots have, up to the present, de-

* I am indebted to my colleague, Dr W. G. Keyworth, who carried out these culture tests.

veloped sporophores on inoculated leaves. From these results it would seem that among the strains of this fungus there are some which rarely, if ever, produce spores.

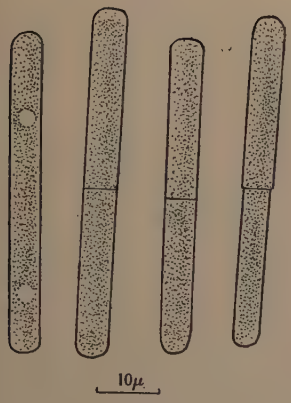
The sporophores are either scattered or in groups of ten to twenty-five. Each sporophore consists of a main axis, unbranched to a height of 48–95μ; several branches then arise at, or near, the same level, while the axis is usually continued beyond this to a total height of 190–285μ and terminates



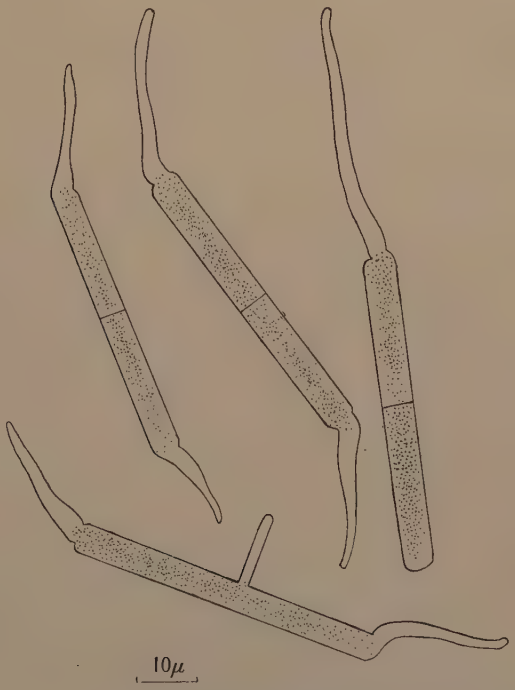
Text-fig. 1. Fructifications of the Plum Shoot Wilt *Cylindrocladium*.

in a pyriform or clavate knob 8–10μ in diameter. The diameter of the sporophores is 6–9μ at the base, tapering to 4 or 5μ just below the branching; the terminal portion of the axis is about 2μ in diameter. The branches are so disposed (with the longest below) that the ultimate branches are approximately at the same height and the spores form a sheaf-like cluster around, or at the side of, the axis. The fertile branches divide cymosely two or three times; the ultimate branches (phialides) are short cells (8–12 × 2–3μ), usually slightly curved, and each terminates in a single conidium (Text-fig. 1). The conidia (phialospores) are cylindrical with rounded ends,

hyaline, and two-celled. From many measurements, taken at various times, the dimensions are found to be within the range 41–64 × 4–6μ, mostly 48–54 × 4·5–5μ. Sometimes one end of a spore is slightly broader than the other by about 0·5μ. In some spores, however, one cell is narrower than the other along its whole length, the difference in width of the two cells being usually about 1·0μ. Some spores show two vacuoles, each about half way between the middle and the end; such a spore may or may not have a cross-wall, but the vacuoles were most clearly seen in spores where the cross-wall had not yet developed (Text-fig. 2).



Text-fig. 2. Types of conidia.



Text-fig. 3. Conidia germinating in water: 4 hr. at room temperature (17° C.).

The conidia germinate readily. In water at room temperature (about 17° C.) they produce germ tubes up to 40μ long within four hours, usually one at each end of a spore and occasionally one near the middle (Text-fig. 3). On prune agar plates at 25° C. there are long loosely branched germ tubes within 24 hr. and in 48 hr. the colonies are from 3 to 4 mm. in diameter.

In its sporophores and spores the fungus shows no great difference from *Cylindrocladium scoparium*, found on a pod of Gleditschia and described by Morgan (1892). The dimensions of the spores are rather greater than those given by him (40–50μ long by 4μ at the tip, 3μ at the base), but this slight divergence may be due to the different conditions under which they developed.

In 1917 Massey described a Crown Canker of roses caused by a species of *Cylindrocladium*; from its morphology he concluded that the rose fungus was *C. scoparium* Morgan; he gives the dimensions of the spores as 36–55 × 3·3–4·5μ, average 48·3 × 4·13μ.

In December 1936, Prof. Massey sent me a culture of the rose fungus isolated by him in July 1935, and in January 1937 I obtained from the Centraalbureau voor Schimmelcultures, Baarn, a culture of Massey's strain of *C. scoparium* received there in April 1918; the latter, presumably, was the original strain isolated by Massey from roses in 1916. The two isolates are similar in cultures, but their habit is quite different from that of the shoot wilt fungus. The growth instead of continuing uniform to the edge of the plate soon becomes irregular by the development of feathery or fan-shaped lobes, and, in addition to small sclerotia-like bodies, they produce large irregular dark brown patches of mycelium (Pl. VI, 3*a*, 3*b*). Both isolates have produced sporophores in agar cultures, a feature, as mentioned above, not yet seen in any of the shoot wilt strains. These cultural characters of Massey's fungus appear to be constant, for not only are they shown by his two isolates, one obtained in 1916 and the other some nineteen years later, but also by a re-isolation by myself from a plum leaf that had been inoculated with the rose fungus.

As Morgan makes no mention of cultural characters, it is impossible to say whether the original *C. scoparium* resembled Massey's rose canker fungus or the plum shoot wilt organism. That these two forms are not identical is shown by their cultural characters, but further study is necessary to determine whether they show other constant differences. Cultures of *Cylindrocladium* were received from Canada, two from strawberry roots and one from a raspberry root.* When grown in culture their habit resembles that of strains isolated at East Malling from plum, cherry, and apricot layer shoots, and not that of the *Cylindrocladium* that attacks roses in the United States. On the other hand an isolate from the roots of wattle (*Acacia mollissima*), sent to the Imperial Mycological Institute from South Africa and supplied by Mr E. M. Mason, behaves in culture rather like Massey's fungus, but it grows out rather more uniformly and rapidly, and has a tendency to develop more aerial mycelium. In all these strains the size of the spores is about the same.

For the present it would appear best to consider the shoot wilt organism as a form of *Cylindrocladium scoparium* Morgan, with the reservation that in its cultural characters it is quite distinct from the form found by Massey on roses.

The form of *Cylindrocladium* isolated from rootstocks has been found, therefore, particularly on species within the family Rosaceae but there is reason for believing that it is not confined to that family. In 1940 a number of lupins died on a small trial plot of cover-crop plants in a field at East Malling where shoot wilt of species of *Prunus* had been prevalent in earlier years. Microsclerotia were present on some of the lupin roots and from three plants isolations were obtained similar to those from plum and cherry

* These cultures were supplied by Dr G. H. Berkeley (St Catharine's, Ontario), Dr J. H. Truscott (Vineland) and Dr L. O. Weaver (University of Toronto).

shoots. As these isolates have not yet produced fructifications, their direct connection with *Cylindrocladium* has not been confirmed, but the cultures in their colour and numerous microsclerotia are so like those obtained from *Cylindrocladium* spores that they are probably the same fungus.

Inoculation experiments

Inoculation experiments were carried out in the years 1939 to 1942. In a preliminary experiment young plum shoots on a Victoria plum tree in the open were inoculated by placing mycelium from an agar plate culture directly on the shoots and making punctures through the inoculum into the shoots. The inoculated spots were then covered with moist cotton wool and tied round with raffia. Within 14 days lesions 0·6–3·5 cm. long and 0·2–0·3 cm. wide developed. Half the inoculated shoots were cut off and the fungus was re-isolated from them. The other lesions made but little further progress and they did not girdle the shoots; later they became covered with callus and there was no wilting. On aerial shoots the conditions are evidently not very favourable for the fungus, but the experiment offered evidence that it was able to infect plum shoots.

Experiments were carried out later on stools raised in large pots in the open. The plants were cut back in winter, and young shoots which grew from them in spring were inoculated. In 1940 the inoculations were made direct on to the axis of the shoot. Meanwhile, however, it was found that the fungus when inoculated into fresh plum leaves (removed from the trees and kept in moist chambers) readily produced lesions, on which, with some strains, *Cylindrocladium* spores developed. In the experiments of 1941 and 1942, therefore, the inoculations were made on the leaves. After inoculation, whether made directly on the shoots or on the leaves, the plants were earthed-up with soil so that the inoculated parts were completely covered. To ensure sufficient height of earthing, sheets of zinc bent to form cylinders were placed round the plants just within the rim of the pots, to receive the added soil.

The most striking results were obtained from inoculation experiments made in 1941. Fourteen plants of Common Mussel plum, in one row, were used; four shoots on each plant were selected, marked with a loop of cotton, and one of the lower leaves of each inoculated. On half the stools the midrib of each leaf for inoculation was severed by a cut about 2 mm. long. On the other plants the inoculum was placed on the midrib without wounding. In each batch of seven plants four were inoculated with the fungus and three were inoculated with sterile agar. The fungus used was the monospore isolate from a Pershore plum leaf. Immediately after inoculation 'steam-sterilized' soil was added to the pots to cover the inoculated leaves to a depth of two to three inches.

The plants were inoculated on 30 May, and on 18 June one inoculated shoot on each of two plants was beginning to wilt. These shoots were pulled up; one had a lesion 4·5 cm. long, dark brown at each end, but greyish with black dots (microsclerotia) towards the middle; the other had a lesion 4 cm. long but no definite sclerotia were visible, although brownish

wart-like swellings suggested sclerotial initials. From both shoots the fungus was re-isolated. Two days later shoots on other inoculated plants began to wilt, and many others died before the end of the month. On 27 June a wilting shoot pulled up from one of the pots had a dark brown lesion 8 cm. long, greyish and bearing microsclerotia towards the middle, and a few fructifications of *Cylindrocladium* near the upper end. About this time some shoots which were quite healthy looking in the morning showed distinct signs of wilting six hours later. In five shoots which showed slight wilting in the afternoon there was recovery by the next morning, but eventually they again wilted, without recovery; this conforms with some other wilt diseases in which infected plants show partial recovery when transpiration is reduced.

The final counts of wilted shoots were made on 29 July (see Pl. VII and Table 1).

Table 1. *Results of inoculation experiment*

Serial no. of stool	Treatment	No. of inoculated shoots wilted (4 shoots inoculated)	No. of shoots not inoculated but wilted	Ratio of no. killed to total no. of shoots
1	Inoculated: wounded	3	10	13/14
2	,, ,,	4	6	10/10
3	Control: wounded	1	1	2/16
4	,, ,,	0	0	0/16
5	Inoculated: wounded	4	13	17/21
6	,, ,,	4	7	11/11
7	Control: wounded	0	0	0/12
8	Control: not wounded	0	0	0/19
9	Inoculated: not wounded	4	11	15/15
10	,, ,,	4	10	14/17
11	Control: not wounded	0	0	0/13
12	,, ,,	1	5	6/26
13	Inoculated: not wounded	4	19	23/23
14	,, ,,	4	11	15/15

Combining these results shows that in inoculated stools 118 shoots died out of 126, or 93·6%, and in the control stools 8 out of 102, or 7·8%.

The most striking features were: (1) The wilting began to appear so early that in the first shoots to wilt the fungus must have infected the inoculated leaf then extended along the petiole into the axis of the shoot to cause a girdling lesion (4·5 cm. long and bearing microsclerotia on one of the shoots examined), all within 18 days. (2) Inoculation without injuring the leaf was as rapid and effective as with wounding; of the first two shoots to wilt one was in stool no. 2 (leaves inoculated with wounding) and the other in no. 13 (leaves inoculated without wounding). (3) Not only did all, except one (in no. 1), of the inoculated shoots succumb but many of those not directly inoculated also wilted.

In five stools (nos. 2, 6. 9, 13, and 14) all the shoots died whether inoculated or not. How the shoots not inoculated became infected could not be seen, from the nature of the experiment. It may be that the fungus grew into and contaminated the soil and that leaves became infected from the soil, or that infection passed by contact from one inoculated leaf to leaves not inoculated on other shoots. In the field the primary source of infection

must be the soil, but possibly the further infection in some instances is transmitted by contact with primarily infected leaves, for wilted shoots are often in small groups suggesting that infection passes from one to others around it.

The wilting of a few shoots in two control pots (nos. 3 and 12) is at present unexplained. The soil used in earthing, although 'steam-sterilized', might not have been quite free from contamination. The stools had been raised in soil not previously sterilized and may have had traces of the fungus in it which attacked leaves coming in contact with it. Again each of the two pots was in close proximity to a pot where all the shoots became affected, and it is not improbable that infection in some way passed from one pot to its neighbour, possibly by splashing when the plants were watered with a hose-pipe.

Control measures

The evidence at present available suggests that the parasite is a soil organism. Stocks from an infected layer row should not therefore be used for starting a fresh plot of layers, since there is the risk that soil on the roots will contain mycelium of the fungus. One way of ensuring starting with clean stocks would be to raise these from cuttings planted out in sterilized soil or on a piece of ground not previously used for stooling or layering plums or cherries. The cuttings, when struck, could be planted out to serve for further layering. This would be a troublesome and lengthy process, particularly as some varieties are not readily propagated from cuttings.

Sterilizing the rooted shoots before planting, by dipping the root systems in a fungicide, is suggested but has not yet been tested.

Spraying the growing shoots at the time of earthing has been tried with some success. Thus in one experiment (carried out in 1943) portions of layer rows, which had shown infection previously, were sprayed with Bordeaux mixture at the time of the two heavy earthings. At the end of the season the percentage of wilted shoots on the control plots was 7·7, that on the sprayed plots 1·1. The results show that spraying with Bordeaux mixture reduces the chances of infection, but the rather dry summer of 1943 was not favourable for the disease so that in this trial the number of infected shoots was low even on the control plots.

It is not yet known whether ground, from which layers that have borne infected shoots have been removed, is unsafe for other plants, but it may be noted that, as already mentioned, a fungus considered by the present writer to conform to the shoot wilt organism has been isolated from raspberry (Berkeley, 1936) and strawberry roots, and it was found by Truscott (1934) to be one of the most virulent of the strawberry root rot fungi. Strawberry plants were planted at East Malling on a layer plot where shoot wilt of plum and cherries was severe, but none became affected with root rot. Such a negative result is mentioned with reserve, and until further experiments along these lines have been undertaken it is considered that planting either strawberries or raspberries on soil infested with the shoot wilt organism should be avoided for some years.

Summary

A *Cylindrocladium* has been isolated from the underground parts of wilted layer shoots of plum, cherry, peach, and apricot, and from plum cuttings.

In its morphology the fungus conforms to *Cylindrocladium scoparium* Morgan. Its habit in cultures, however, is quite distinct from the fungus, referred to *C. scoparium*, isolated by Massey from roses.

Experiments have shown that the typical symptoms of the disease can be induced by inoculating the lower leaves of shoots on plum stools in pots and then covering them with soil.

Measures for the control of the disease are suggested.

I wish to express my indebtedness to Miss E. M. Wakefield and Mr W. C. Moore for help with the literature.

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EXPLANATION OF PLATES V–VIII

Plate V. *Cylindrocladium* Shoot Wilt in a plum layer row; natural infection.

Plate VI. Cultures of *Cylindrocladium* on prune agar. 1*a*. Monospore strain from a leaf on a plum cutting. × ⅔. 1*b*. Portion of culture shown in 1*a*. × 5. 2*a*. Strain isolated from a lesion on a plum layer shoot. × ⅔. 2*b*. Portion of culture shown in 2*a*. × 5. 3*a*. *C. scoparium*, Massey's strain from rose. × ⅔. 3*b*. Portion of culture shown in 3*a*. × 5.

Plates VII and VIII. Pots of plum stools from an inoculation experiment (see description on p. 78). A. Inoculated, leaves injured: pots nos. 1 and 2. All shoots except one withered. B. Control; pots nos. 11 and 12. Shoots all alive in no. 11; six withered in no. 12, but now hidden by the healthy shoots. C. Inoculated, leaves not injured; pots nos. 13 and 14. All shoots withered.

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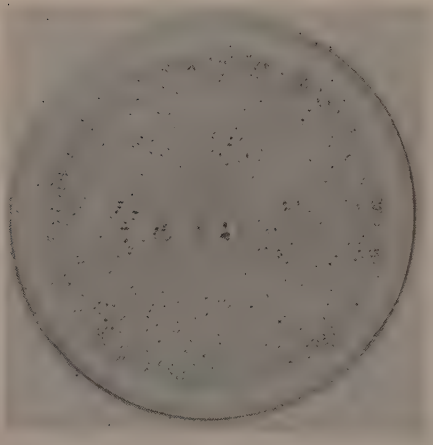


Fig. 1 *a*.

Fig. 1 *b*.

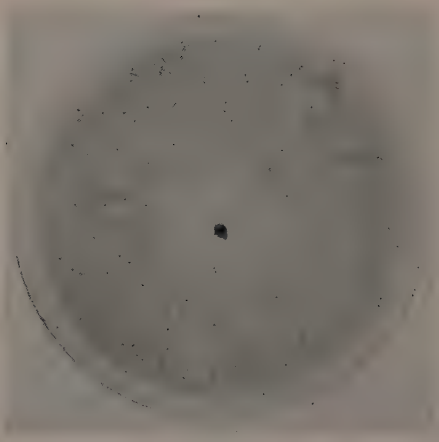


Fig. 2 *a*.

Fig. 2 *b*.

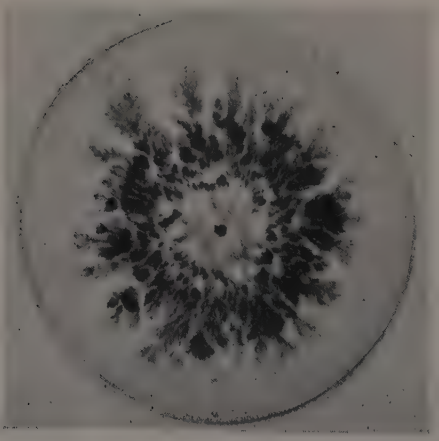


Fig. 3 *a*.

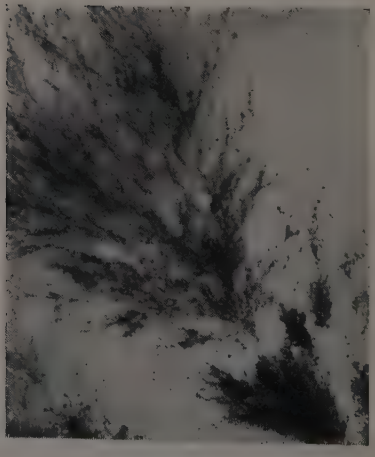


Fig. 3 *b*.

A.

B.

C.

NOTES ON ENTOMOGENOUS FUNGI

By T. PETCH

181. *Cordyceps sphecocephala* (Klotzsch) Cooke

The only reputed British specimen of this species is in the Herbarium of the British Museum, and as it is not localized its British origin is doubtful. Mr E. A. Ellis collected another specimen at Wheatfen Broad, 20 September 1942, among dead leaves, free from any host but undoubtedly this species. The stalk is pale ochraceous, compressed, and the head is pale brown, ovoid, tuberculate with the apices of the oblique perithecia. The lower edge of the head is produced downwards as a collar round the apex of the stalk, thus resembling the specimens in Herb. Berlin recorded in *Trans. Brit. Myc. Soc.* xviii, 62 (1933). *Teste* Mr Ellis, the part-spores in his specimen are lanceolate, ends obtuse, $7{\cdot}5 \times 1{\cdot}5\mu$.

In *Trans. Brit. Myc. Soc.* xxi, 55 (1937), I recorded that *Isaria sphecophila* Ditm. is a *Hymenostilbe*, and that it is the conidial stage of *Cordyceps sphecocephala*. Conidial forms associated with *C. Ditmari* were described in *Trans. Brit. Myc. Soc.* xvi, 220 (1932), where it was stated that they belonged to *Hymenostilbe*. Kobayasi (*The Genus* Cordyceps *and its Allies*, p. 149, 1941) writes, under *Cordyceps Ditmari*, 'Quélet referred the conidial state of this species to *Isaria sphecophila* Ditm., and Massee agreed with it. *Isaria sphecophila* is, however, transferred into *Hymenostilbe* by Petch and at present is regarded as the conidial state of *Cordyceps sphecocephala*. Accordingly the Isarial fungus described and figured by Quélet awaits a further study to decide to what genus [it] should belong.' But now that *Isaria sphecophila* is definitely known, it is evident that the conidial form associated with *Cordyceps Ditmari* is indistinguishable from it, Quélet's description of the conidia being an error. *Cordyceps armeniaca*, *C. Ditmari* and *C. Langloisii* are merely forms of *C. sphecocephala*. Massee quoted Quélet, and added: 'I have received a *Cordyceps* agreeing exactly with Quélet's description, and accompanied by *Isaria sphecophila* Ditm. from Ireland, collected by Dr McWeeney. It was growing on the remains of a large bluebottle-like fly.' Obviously, Massee did not know *Cordyceps Ditmari* or *Isaria sphecophila*. What he had were probably *Cordyceps Forquignoni* and *Hymenostilbe muscaria*, though these do not fit Quélet's figures and descriptions.

182. *Cordyceps tuberculata* (Lebert) Maire

Records of this species for Britain, as *Cordyceps Sphingum*, are based on Berkeley and Broome's record of the conidial stage, *Isaria Sphingum*, in *Notices of British Fungi*, no. 1710 (1878), 'on pupae of Diptera, Kincardineshire, Mr Taylor'. That specimen is now in Herb. Kew. The pupae, if present, are hidden in debris. The specimen bears small, slender, terete clavae, clothed below with spicarioid conidiophores with flask-shaped phialides, $6 \times 2\mu$, and oval, subacute conidia, $1{\cdot}5$–$2{\cdot}5 \times 1\mu$. This is a linear

form of *Spicaria* (*Isaria*) *farinosa*, and Berkeley and Broome's identification was incorrect. Moth scales are present on the specimen, and the host was probably misidentified.

I have received specimens of *Cordyceps tuberculata* from Mr E. A. Ellis, on pupae of Lepidoptera, Alderfen Broad, Norfolk, 15 August 1940, Osier Carr, Wheatfen Broad, 18 October 1942, and Low Common, Hellington, near Norwich, 9 May 1943. The clavae are at first narrow clavate, up to 9 mm. high, white, dotted with the yellow ostiola of the perithecia. Subsequently, the perithecia become superficial, pale yellow, crowded, making an ovoid or cylindrical head of closely packed perithecia.

The pupa from Hellington bears conidial clavae as well as perithecial clavae, and these are *Isaria Sphingum* Schwein. (1822), *Akanthomyces aculeata* Lebert (1858) and *Hymenostilbe Sphingum* (Schwein.) Petch (1932). *Akanthomyces* is distinct from *Hymenostilbe* (see later), and this species must now be known as *Akanthomyces Sphingum* (Schwein.) Petch, comb.nov.

183. *Cordyceps militaris* var. *sphaerocephala*

This was described as a species, *Sphaeria sphaerocephala*, by Kunze and Schmidt, and was placed as a variety of *Cordyceps militaris* by Fries. It is characterized by its long, thin stalk and globose head.

Forms of *C. militaris* with a short stalk and a globose head are not uncommon, but no one has considered them worthy of varietal rank. I have recently examined a specimen of *C. militaris* collected by Mr E. A. Ellis at Wheatfen Broad, 24 August 1939, which has a stalk, 3 cm. long, 0·75 mm. diameter, with a *clavate* head, 1 cm. long, 2 mm. diameter. Thus a long thin stalk is not necessarily associated with a globose head, nor a globose head with a long stalk. Consequently the variety *sphaerocephala* is not worthy of retention.

184. *Akanthomyces* and *Hymenostilbe*

The genus *Akanthomyces* was established by Lebert in 1858 for a species, *A. aculeata* Lebert, found on a moth in Europe. An account of it with details of British specimens was published in *Trans. Brit. Myc. Soc.* xviii, 72 (1933). The genus was not included by Saccardo in *Sylloge Fungorum*, and for a long time Lebert's record was overlooked. Thaxter (*Mon. Laboulb.* i, 359), when substituting *Rhachomyces* for *Acanthomyces* Thaxter because of the prior use of *Akanthomyces* by Lebert, stated that Lebert's fungus was 'probably identical with *Isaria Sphingum*'. That seemed to me doubtful, but examination of further specimens of both species has convinced me that Thaxter's view was correct. The conidial stage of *Cordyceps tuberculatum* (Lebert) Maire must be known as *Akanthomyces Sphingum* (Schwein.) Petch. Lebert described *A. aculeata* and *Cordyceps tuberculata* (as *Akrophyton tuberculatum*) in the same paper but without any suggestion of their possible relationship, and apparently his specimen of the former was European and that of the latter American. Details of *Cordyceps tuberculata* and its conidial stage were given in *Trans. Brit. Mycol. Soc.* xvi, 213 (1932).

In *The Naturalist* (1931), p. 101, I described a new genus *Hymenostilbe*, with the species *H. muscaria*, for a conidial fungus on Diptera which has

since been found to be the conidial stage of *Cordyceps Forquignoni* Quélet, and in the note on *Akanthomyces* cited above I stated that it appeared doubtful whether it would be possible to maintain *Hymenostilbe* Petch distinct from *Akanthomyces* Lebert. Nine species of *Hymenostilbe* are now known, several of them conidial forms of species of *Cordyceps*, and it is now clear that the two genera must be maintained, the most important distinction being that *Akanthomyces* has its conidia in chains, while those of *Hymenostilbe* are solitary on the phialide or basidium. Only one species of *Akanthomyces* is known at present.

Fries, in *Syst. Mycol.* III, 274 (1832), described two species of '*Isaria*', *I. floccosa* and *I. strigosa*, which are still unknown. Both occurred on Lepidoptera. They were discussed in *Trans. Brit. Mycol. Soc.* XVIII, 70 (1933). A specimen of *Akanthomyces Sphingum*, 'White Hill, Auchter House, Dundee, nov. subfin., 1847, G. Lawson', is included in the cover of *Isaria floccosa* in Herb. Kew., while a specimen from Sachsenwald near Hamburg, October 1907, coll. O. Jaap, is included in the cover of *Isaria strigosa* in Herb. Berlin. Thus *Akanthomyces Sphingum* has been taken by different mycologists as *Isaria floccosa* and as *I. strigosa*.

Isaria floccosa was said by Fries to have almost the appearance of a *Hydnum*, with spines, 2–4 mm. long. The spines (clavae) were subulate, simple, everywhere floccoso-tomentose. It differed from *Isaria arachnophila* Ditmar (*Hymenostilbe arachnophila* (Ditm.) Petch) in having acute clavae, but especially in its floccose appearance, for on old specimens the conidia were abundant, though under a low magnification the clava appeared only floccose. The comparison is not very enlightening, for Ditmar's figure shows the clava of his species dripping with masses of conidia.

Isaria strigosa was said by Fries to be altogether different from *I. floccosa*. The subulate clavae arose from a subdeterminate patch of mycelium, and were simple, or fasciculate and consequently branched, at first subdecumbent, slender, 4–6 mm. long. The surface of the clava was everywhere the same, almost naked, but when magnified pubescent and conidiiferous, becoming glabrous when old.

There is nothing in the two descriptions which would not agree with forms of *Akanthomyces Sphingum*, and in the absence of type specimens the best solution of the problem would be to regard *Isaria floccosa* and *I. strigosa* as synonyms of that name.

185. *TORRUBIELLA FLAVOVIRIDIS* (Möller) Kobayasi

Möller (*Phycomyceten und Ascomyceten*, p. 208) stated that this species belonged to *Torrubiella* Boud., but he described it as *Cordyceps* as he did not consider the genus *Torrubiella* necessary. Kobayasi appears to have been the first to make the combination. Some account of it was given in *Trans. Brit. Myc. Soc.* XIX, 162 (1935), where it was suggested that it grew on a spider and might be a form of *Cordyceps Engleriana* P. Henn. Möller thought that his example had developed from two small insect pupae, but an examination of the type, through the glass of a museum jar, showed that it arose from a spider tent and was probably parasitic on a spider, the two pupae, apparently dipterous, being intrusive.

I have recently been able to examine a specimen of *Torrubiella flavoviridis* from British Guiana, collected by Mr N. Y. Sandwith, 12 August 1937. It is on a spider which is covered by white or pale yellow mycelium, forming a somewhat compact pulvinate stroma with a definite margin, and the perithecia are almost superficial, in small linear groups of two or three, usually near the margin of the stroma. The perithecia are large, up to 1 mm. high and 0·25 mm. broad, cylindrical, slightly contracted at the base, clothed nearly to the apex with a tomentum, now white, of variously curled hyphae, the apex being obtusely conical, naked and yellow. In this specimen the perithecia are laterally compressed, being oval in transverse section, measuring, for example, 0·25 × 0·12 mm. That may be due to a collapse in drying, but I have not previously observed such a regular collapse in any other species. The specimen had not been pressed. Möller did not mention the tomentum on the perithecium, but his description is deficient in details and his figure shows clearly the upper limit of the tomentum. The asci are linear-cylindrical, capitate, four- or eight-spored, 4–8 μ diameter, and the part-spores are lanceolate, 10–14 × 1·5 μ. The type of spore is that given by Kobayasi for his section *Neocordyceps*.

This particular specimen is overrun by an *Aspergillus*, and hyphae with inflated tips found among the tomentum are the old conidiophores of the *Aspergillus*. Entomogenous fungi from the tropics, if not dried rapidly, are soon overrun by *Aspergillus* or *Penicillium* during drying. That appears to be especially so with South American specimens, and the 'conidial stages' figured by Hennings for *Cordyceps Amazonica* and *C. juruensis* in *Fungi Amazonici*, II, *Hedwigia*, XLIII, 247, 248 (1904) are intrusive *Aspergillus* and *Penicillium*.

186. **Torrubiella albolanata** Petch, n.sp.

In *British Hypocreales*, one species of *Torrubiella*, *T. aranicida* Boud., which occurs on spiders, was recorded for this country from Hubberholme, Yorks. Recently Mr E. A. Ellis has made several collections of another species of *Torrubiella* on spiders, usually on *Gongylidium rufipes*, but in one instance on Thomisidae, in various localities on Wheatfen Broad, 21 June 1942, 9 and 13 August 1942, and 14 June 1943.

The fungus covers the body of the spider with a continuous, loose, white, tomentose stroma of intertwined hyphae. Usually the perithecia are almost completely immersed in the stroma, only the pallid or yellowish ostiola being visible, but sometimes they project and are clothed nearly to the apex with loose hyphae similar to those of the stroma. These hyphae are regular, 1·5–2 μ diameter, minutely rough, bifurcating or branching irregularly above. The perithecia are conoid, 0·5 mm. high, 0·25 mm. diameter, moderately crowded. The asci are linear-cylindrical, capitate, and when mature 4–5 μ diameter. The mature ascospores are wound in a very flat spiral, and the part-spores are cylindrical or lanceolate, ends obtuse, 5–7 × 1–1·5 μ. I name this species, *Torrubiella albolanata*.

Some of the stromata are conidial only. These resemble the perithecial stromata but lack perithecia. The branching hyphae terminate in conoid or slightly flask-shaped segments 12–18 μ long, 2–2·5 μ diameter, each

bearing an apical, cylindrical, hyaline conidium, 7–10 × 0·75–1 μ. Similar conidia occur on the hyphae between the perithecia, and the conidiiferous tips are sometimes clustered on the perithecial wall. This is a *Cylindrophora*, which may be known as *C. aranearum* n.sp.

Torrubiella aranicida differs from the present species in its longer, conoid or distinctly flask-shaped perithecia and in its perithecial wall, which is glabrous, evidently parenchymatous, of polygonal cells, 12–20 μ diameter, or transversely oval cells, 20 × 12 μ, with walls, 1–2 μ thick. Its perithecia are pellucid when fresh but dull orange when dry, and are scattered or clustered on a thin whitish or yellowish byssoid subiculum. Conidia have not been found on the available specimens.

On the other hand, the conidial hyphae of *T. albolanata* bear a remarkable resemblance to *Isaria cuneispora* Boud., the recorded conidial stage of *Torrubiella aranicida*. Boudier described the hyphae of his species as minutely rough, and the alleged conidia as elongated conoid, not or scarcely rough, attached by the thicker base, 12–14 × 2–2·5 μ. The terminal segments of the hyphae of *T. albolanata* resemble in size and shape Boudier's 'cuneiform conidia', and it would seem possible that *Isaria cuneispora* is a *Cylindrophora*, the real conidia of which were not observed. Boudier collected the *Isaria* two years later than the *Torrubiella*, though in the same locality, and he stated that the best time for the latter was summer or the beginning of autumn, but he found the *Isaria* in March. Consequently there is the possibility that he collected the perithecia of *Torrubiella aranicida* and the conidial stage of *T. albolanata*.

Torrubiella albolanata Petch, sp.nov. Mycelio albo, laxo, limitato, tomentoso, hyphis regularibus, 1·5–2 μ diam., ramosis, minute verrucosis, intertextis; peritheciis immersis v. exsertis et albo-lanatis, pallidis, gregariis, conoideis, 0·5 mm. alt., 0·25 mm. diam.; ascis cylindraceis, capitatis, praelongis, maturitate 4–5 μ diam.; ascosporis maturitate in spiram subplanum convolutis; articulis ascosporarum cylindraceis v. lanceolatis, obtusis, 5–7 × 1–1·5 μ.

On spiders, Britain.

Cylindrophora aranearum Petch, sp.nov. Mycelio albo, laxo, limitato, tomentoso, hyphis regularibus, 1·5–2 μ diam., ramosis, minute verrucosis, intertextis; segmentis terminalibus hypharum conoideis v. angusto-ampullaceis, 12–18 × 2–2·5 μ; conidiis hyalinis, apicalibus, solitariis (? semper), bacillaribus, 7–10 × 0·75–1 μ.

On spiders; the conidial stage of *Torrubiella albolanata* Petch.

187. **Torrubiella albotomentosa** Petch, n.sp.

This, the third British species of *Torrubiella*, was found by Mr E. A. Ellis on a small dipterous pupa lodged in a dead stem of *Glyceria maxima* at Parish Marsh, Wheatfen Broad, 30 May 1943. The perithecia are clustered, divergent, without evident stroma or subiculum, flask-shaped, 0·5 mm. high, 0·25 mm. diameter, white or pallid, minutely white tomentose with short, contorted and variously inflated hyphae. The immature asci are linear, cylindrical, capitate, 200–220 μ long, 3–4 μ diameter, with linear

ascospores, 0·75 μ diameter. The spores were not sufficiently mature to show septa or part-spores.

Torrubiella albotomentosa Petch, sp.nov. Peritheciis caespitosis divergentibus, ampullaceis, 0·5 mm. alt., 0·25 mm. diam., albis v. pallidis, minute albo-tomentosis, hyphis brevibus contortis et varie inflatis vestitis; asci cylindraceis, capitatis, 200–220 μ long., 3–4 μ diam.; ascosporis linearibus, 0·75 μ diam. (immaturis).

On a dipterous pupa, Britain.

A similar pupa, found by Mr Ellis in the stem base of *Glyceria maxima* at Home Marsh, Wheatfen Broad, 19 June 1943, bears minute pulvinate cushions, elongated oval in plan, up to 0·75 mm. long, 0·25 mm. broad, minutely tomentose, white or yellowish white, brownish yellow at the base, composed of interlacing, curved, hyaline hyphae, 2·5 μ diameter. These hyphae bear scattered lateral branches, similar to the terminal segments of the hyphae, which are conoid or narrow flask-shaped, 7–12 × 1·5–2 μ, with a long, thin neck. This would appear to be another species of *Cylindrophora*. Numerous conidia were present, but I was unable to find one attached; they were hyaline, cylindrical with rounded ends, usually attenuated slightly but uniformly towards the middle, 6–10 × 2·5–3 μ. Whether these are actually the conidia of the fungus which forms the cushions must remain undecided until further specimens are available, as numerous conidia of other fungi, e.g. *Mastigosporium*, collect round entomogenous fungi found in such situations.

188. *Empusa tenthredinis* (Fres.) Thaxter

This species, which occurs on the larvae of sawflies (Hymenoptera), was described by Fresenius as *Entomophthora* and was transferred to *Empusa* by Thaxter. It is apparently a rare species, and Fresenius's record in 1858, on *Tenthredo* larvae on alder in September, appears to have been the only one until Thaxter found a single specimen on a *Tenthredo* larva on *Scutellaria* in September in a swampy situation among woods in Maine and recorded it in 1888. The conidia are ovoid, with a prominent papilla, and according to Thaxter vary from 35 × 25 μ to 55 × 35 μ. Fresenius, *teste* Thaxter, gave the maximum length as 62·5 μ.

On 14 June 1943, Mr E. A. Ellis found two examples of this species on sawfly larvae on *Spiraea ulmaria* at Parish Marsh, Wheatfen Broad, Norfolk. The conidia measured 32–44 × 30–32 μ, but I did not obtain a good spore print. Another example was found by Mr Ellis on the same plant in the same locality on 27 June 1943. In the latter specimen, the conidia had been abjected, and some were collected in a yellowish mass on the leaf. These conidia measured 33–45 × 22–30 μ; it is possible that some of these were secondary conidia, which are the same shape as the primary. Several of these conidia had germinated and had produced resting spores (azygospores), oval, 30–33 × 25–27 μ, or globose, 27–36 μ, hyaline, smooth, with a wall up to 4 μ thick. The conidiophores are simple, and at first form a short velvety pile over the larva, ultimately coalescing in a pale brown mass.

In *Ann. Mycol.* iv, 105 (1906), Bubák described *Entomophthora Cimbicis*,

which occurred in the chrysalides of *Cimbex* sp. (sawflies) in Bohemia. Only resting spores were found, and consequently Lakon changed the name to *Tarichium Cimbicis* in *Zeitschr. f. Pflanzenkr.* xxv, 257 (1915). The resting spores were described as globose or slightly ellipsoid, yellowish, 26–48 × 24–32 μ, with a thin wall, 1–1·5 μ thick. It would seem possible that this is the resting spore form of *Empusa Tenthredinis*.

189. **Empusa acaridis** Petch, n.sp.

A single example of this species was collected by Mr E. A. Ellis, on a mite, *Pergamasus crassipes* L., at Wheatfen Broad, Norfolk, 9 August 1942. The conidiophores emerged along the edge of the body, forming a narrow swollen cushion, especially round the hinder end; they appeared to arise from an external stroma, but that could not be determined with certainty from the material available. The conidia were broadly oval, 16–22 × 11–13 μ, with a broad, convex, slightly elevated papilla. There were no rhizoids and no sign of any attachment.

Empusa acaridis Petch, sp.nov. Conidiophoris circum corpus praecipue postice emergentibus; conidiis late ovalibus, 16–22 × 11–13 μ, papilla lata convexa parum elevata; hyphis rhizoideis nullis.

On a mite (Acarid), England.

190. *Entomophthora Forficulae* Giard

According to Giard, this species, which was found on earwigs adhering to plants near Boulogne, has oblong or long elliptical conidia with rounded ends, the base scarcely different from the apex, without oil globules, strongly but uniformly refringent, 20–25 × 6–8 μ. The conidiophores are short and sparingly branched, and emerge from all the junctions of the chitinous plates of the host. The insects were attached to the plants by the thorax, the feet and the antennae, but Giard was unable to find rhizoids.

Rostrup, who recorded this species in *Medd. naturh. Foren.* [*Copenhagen*], 1893, p. 87, from three localities in Denmark, gave the conidia as 18–21 × 8–10 μ, with a vacuole at each end. Guégen, in *Champignons parasites*, p. 63, 1904, queried its reference to *Entomophthora*, and on the available data that appears justified. It must be placed in *Empusa*, as *Empusa Forficulae* (Giard) Petch, comb.nov.

Mr E. A. Ellis, on 10 August 1942, obtained two specimens of an *Empusa* on earwigs at Old Lakenham, Norfolk, which agree macroscopically with Giard's description. The conidiophores emerge from all sutures and ultimately coalesce in part over the body; as far as I could determine they are unbranched. The insects were detached when received, but had apparently been attached by their feet, rhizoids being absent. The conidia were ellipsoid, scarcely papillate, or with a broad, flattened convex papilla occupying the whole breadth of the base, but they measured 20–30 × 15–18 μ. The resemblance to Giard's species is too close to permit the proposal of a new species, and this form may be known as *Empusa Forficulae* var. *major* Petch, var.nov.

191. *Entomophthora occidentalis* Thaxter

This species was collected by Mr E. A. Ellis on aphides on *Ranunculus repens*, Old Lakenham marshes, 26 July 1942. This is the second recorded occurrence in England.

192. *Entomophthora virescens* Thaxter

During a plague of caterpillars on *Brassica* at North Wootton in September 1942, a single example of *Entomophthora virescens* Thaxter was found. The fungus was pale green and completely covered the larva, the mass of conidiophores and rhizoids descending to the leaf on both sides of it and forming a roof-like structure with sloping sides and a central longitudinal ridge. The free conidia on the adjacent parts of the leaf were greenish yellow in mass, oval, 18–27 × 8–13 μ, but the specimen was over-mature, and it could not be determined whether these were primary or secondary conidia.

It may be noted that large numbers of caterpillars died from a 'wilt' disease, but I was not able to find in them the polyhedra which occur in the wilt diseases of caterpillars in the United States of America and in Ceylon.

193. *Entomophthora coleopterorum* Petch

This species was described in *Trans. Brit. Myc. Soc.* xvii, 172 (1932) from a specimen containing resting spores only. It had the peculiarity of being attached to the substratum by definite fascicles of rhizoids which emerged from two points on the lower surface of the body of the insect and spread out in a more or less conical bundle. The distal ends of the rhizoids were stout, but not expanded into plates. The resting spores were dark brown, thick-walled (up to 6 μ), densely verrucose, globose, 35–50 μ diameter, or broadly oval, 48–52 × 44–46 μ, or sometimes pyriform, 56 × 44 μ. Since that publication other examples have been collected which are probably the same species, as they have the same peculiar attachment, though the number of fascicles of rhizoids may be more than two. These specimens, however, are conidial only. One is on coleopterous larvae on a living leaf, collected at Lartington, Yorks, 16 September 1933, another on weevils, *Sitones flavescens*, Wick, 10 October 1937 (Miss D. J. Jackson). The conidiophores appear in minute tufts, ultimately coalescing over the body of the insect. The conidia are narrow oval, 32–44 × 8–14 μ. Cystidia, 10 μ diameter, tapering upwards, are present.

It is probable that this is the same as *Entomophthora Carpentieri* Giard, a name proposed by Giard in *Bull. Sci. Fr. et Belg.* 1888, p. 296, without description, for a species found on *Agriotes spectator* and *Elater* sp. Giard stated that the insects were attached to plants by a small tuft of very stout rhizoids which emerged at definite points on the ventral surface, especially at the junction of the prothorax and the mesothorax, while a second tuft was often present behind the pair of metathoracic legs. Because of this mode of attachment, Giard proposed a new subgenus, *Lophorhiza*.

194. **Entomophthora anglica** Petch, n.sp.

This species has occurred on beetles on several occasions, and, as no description has been found to fit it, it is necessary to describe it as new. The mode of attachment to the plant varies according to the degree of development of the fungus. At first the beetle is attached by rhizoids from the head, and it sometimes grasps the plant by its mandibles. As the fungus develops, rhizoids are produced from the ventral surface and the sides, while there is often a strong growth of coarse strands spreading from the head and thorax. The conidiophores in fully developed examples extend in a continuous sheet from the sides of the body to the substratum, but in general they do not spread over the elytra or only partially along their outer edges. The primary conidia from a spore print were oval, narrow oval or subfusoid, sometimes slightly bent, with a broad, truncate papilla, 22–27 × 11–13 μ, while the secondary conidia were the same shape but shorter, 18–21 × 10–11 μ. Measurements of conidia taken directly from the insect on various occasions gave a total variation of 18–27 × 8–13 μ.

I have had this species on a beetle (? *Plateumeris*) on meadowsweet, Hornsea, E. Yorks, 14 July 1931; on *Agriotes sputator*, Coton, Cambs, 3 May 1931 and June 1933 (E. W. Jones); type, on ? *Plateumeris*, Pickering, 6 June 1938 (W. G. Bramley); on a heather beetle, *Lochnoea suturalis*, Edinburgh, June 1939 (R. W. G. Dennis); on *Cantharis* sp., Old Lakenham, 25 June 1942 (E. A. Ellis); on a Staphylinid, Wheatfen Broad, 9 August 1942 (E. A. Ellis). The specimens on *Agriotes* were recorded in *Trans. Brit. Myc. Soc.* XVII, 171, as *Entomophthora Lampyridarum* Thaxt., because of the mode of attachment, but the latter has larger conidia (30–37 μ × 14–20 μ) and its secondary conidia are a different shape; the name must be deleted from the British list.

Entomophthora Nebriae Raunkiaer, found on *Nebria brevicollis* in Denmark, would appear from the description to have conidia similar to those of *E. anglica*, but larger, 28–37 × 10–13 μ, and it has pale brown, smooth, globose, resting spores, 35–50 μ diameter, produced outside the body of the host.

Entomophthora anglica Petch, n.sp. Insectum primum hyphis rhizoideis antice adfixum, dein conidiophoris et hyphis rhizoideis omnino circumdatum; conidiis primariis ovalibus, angusto-ovalibus vel subfusoideis, interdum leniter curvatis, 22–27 × 11–13 μ, papilla lata truncata, conidiis secundariis similibus sed brevioribus, 18–21 × 10–11 μ.

On Coleoptera, Britain.

195. **Spicaria stricta** Petch, n.sp.

Mr E. A. Ellis collected this species on a spider at Poor's Marsh, Wheatfen Broad, 13 August 1942. The fungus covered the body and legs of the host with a greyish white, farinose weft. The repent hyphae are hyaline, 4 μ diameter, and bear stout scattered conidiophores, up to 150 μ high, 3–4 μ diameter below, 2 μ diameter towards the apex, sometimes widely branched below, the main stem and branches bearing in their upper part rather closely set, short lateral branches terminated by a cluster of

phialides producing chains of conidia, those on each stem forming a subcylindrical head. The phialides are oval, 5–6 × 2–3 μ, and the conidia narrow oval or oblong oval, hyaline, catenulate, ends truncate in the chain but becoming rounded, 4–5 × 1·5–2 μ.

Spicaria stricta Petch, sp.nov. Mycelio cinereo-albo, farinaceo, insectum obducente; hyphis repentibus hyalinis, 4 μ diam.; conidiophoris ad 150 μ alt., infra 3–4 μ diam., supra 2 μ diam., simplicibus vel infra late furcatis, prope apicem ramos laterales breves approximatos phialidibus coronatos ferentibus; phialidibus ovalibus, 5–6 × 2–3 μ; conidiis angusto-ovalibus vel oblongo-ovalibus, hyalinis, catenulatis, in catena truncatis, dein rotundatis, 4–5 × 1·5–2 μ.

On a spider, England.

196. *Spicaria* (*Isaria*) *fumoso-rosea* (Wize) Vassil.

Wize described this species, as *Isaria*, in *Bull. Acad. Cracovie* (1905), 354, fig. 7, Pl. X, fig. 4, from specimens on the larva of a beetle, *Cleonus punctiventris*. It was transferred to *Spicaria* in *Morbi Plantarum, Leningrad*, xviii, 113–48, 9 figs. (1929) by Vassilievsky, who found it on pupae of cabbage flies, *Hylemyia floralis* and *H. brassicae*, and stated that it was indistinguishable morphologically from *Spicaria Aphodii* Vuill. Vuillemin had described the latter in *Bull. Soc. Sci. Nancy*, xi, 147–52, figs. 1–12, from specimens on the beetle, *Aphodius fimetarius*. Further information about *Spicaria fumoso-rosea* was given in *Archiv. Biol. Soc. Sc. Lett. Varsovie*, vi, fasc. 1, 57, Pl. I, fig. 14, Pl. III, fig. 8 (1937) by Siemaszko, who recorded it on several species of lepidoptera as well as on beetles.

Mr E. A. Ellis has submitted to me numerous specimens from Wheatfen Broad, September 1937 and August–October 1942, which appear to be referable to this species, generally on glow-worms, the larvae of *Lampyris noctiluca*, but once on a pupa which may be lepidopterous. The clavae arise from continuous stromata along the sutures, and are of two forms, though both forms sometimes occur together on the same larva. In the one form, thin, feathery, simple clavae, up to 15 mm. long arise together in a tuft. The central stem of a clava is 0·2 mm. diameter at the base, diminishing above to 0·1 mm., pinkish ochraceous, and is covered with scattered conidiophores, up to 150 μ long, perpendicular to the clava, farinose with white masses of conidia. The conidiophore is spicarioid, with lateral and terminal clusters of phialides which are flask-shaped, 8–9 × 2–3 μ, and bear chains of oval, oblong oval or subfusoid, hyaline conidia, usually obtuse, 4–7 × 1·5–2·5 μ. In the other form, the clavae are short and stout, up to 5 mm. long, 0·3 mm. diameter, terete or flattened, simple, or forked above, and in the flattened clavae the conidiophores tend to be concentrated along the edges, while at the apex they are crowded, more or less parallel, and constitute a palisade layer.

I refer this species to *Spicaria fumoso-rosea* with some doubt. It appears to agree in morphological characters, but the conidia are white in mass. Wize described the colour of the conidia as smoky rose, and Vuillemin as rose, and the disease caused by the fungus is known as the pink muscardine. But, until Russian specimens are available for comparison, it seems ad-

visable to place it under Wize's name rather than to describe it as a new species. The phialides resemble those of *Spicaria* (*Isaria*) *farinosa*, but the conidia are much larger than those of the latter, and of a different shape.

197. **Cylindrodendrum suffultum** Petch, n.sp.

Numerous examples of this species on dipterous pupae, chiefly Psychodidae were collected by Mr E. A. Ellis in August 1942 in several localities near Norwich—Trowse marshes, and Home Marsh and Poor's Marsh, Wheatfen Broad. On these small pupae it forms minute, white, tomentose tufts, which afterwards become confluent, along the sutures. But in a collection on larger Tipulid pupae, Wheatfen Broad, 19 June 1943, some of the tufts grow on into loose isarioid clavae, up to 2 mm. long, usually decumbent or prostrate. The hyphae are hyaline, lax, intertwined, branched, septate, 3–4 μ diameter, and bear whorls of prophialides and phialides, with an apical cluster of phialides. The prophialides are inflated, ovoid, inequilateral, about $6 \times 5 \mu$, each bearing one or more phialides, which are flask-shaped, $7–12 \times 4 \mu$, with a truncate base. The apical cluster sometimes consists of two phialides only, arising from the obtuse apex of the terminal segment of the hypha. On the smaller pupae, the conidia are hyaline, oblong or oblong-oval, $6–9 \times 4 \mu$, or globose, 5 μ diameter, not catenulate; on the larger pupae they are $8–12 \times 3–4 \mu$.

Cylindrodendrum suffultum Petch, sp.nov. Caespitibus minutis, albis, tomentosis, discretis dein confluentibus, interdum in clavas laxas, ad 2 mm. long., decumbentes v. procumbentes, productis; hyphis hyalinis, laxis, intertextis, ramosis, septatis, 3–4 μ diam., prophialides et phialides verticillatim ferentibus; prophialidibus inflatis, ovoideis, inaequilateralibus, circa $6 \times 5 \mu$; phialidibus ampullaceis, basi truncatis, $7–12 \times 4 \mu$; conidiis hyalinis, oblongis v. oblongo-ovalibus, $6–12 \times 3–4 \mu$, v. globosis, 5 μ diam.

On pupae of Diptera, Britain.

198. **Verticillium larvarum** Petch, n.sp.

This species occurred on a lepidopterous larva (Nettle Grub) at Nuwara Eliya, Ceylon, 11 September 1927, and a second specimen was collected in the same district on a different lepidopterous larva, 9 September 1928.

The larva is sparsely covered with yellow or ochraceous mycelium, which here and there forms short, loose, clavate tufts or processes. The conidiophores are erect, rigid, up to 120 μ high, 2·5 μ diameter, with opposite or ternate simple branches near the apex, the branches being narrow flask-shaped, up to 18 μ long, 1·5 μ diameter, tapering to the apex and bearing the conidia in a small head. The conidia are broadly oval, ends rounded, or oblong-oval, hyaline, continuous, $2–5 \times 1·5–2 \mu$. In the second specimen some of the longer conidia are up to 7 μ long and one-septate. When mounted, the head of conidia sometimes collapses into a band, with the conidia parallel.

Verticillium larvarum Petch, n.sp. Mycelio flavo v. ochraceo, larvam sparse obducente, hic illic caespites laxos breves clavatos formante; conidiophoris erectis rigidis, ad 120 μ alt., 2·5 μ diam., supra ramosis, ramis oppositis v. ternatis, anguste ampullaceis, ad 18 μ long., 1·5 μ diam., ad

apicem attenuatis, conidia in capite parvo ferentibus; conidiis hyalinis, continuis, late ovalibus, utrinque obtusis, v. oblongo-ovalibus, 2–5 × 1·5–2 μ, interdum 7 μ longis et uniseptatis.

On lepidopterous larvae, Ceylon.

199. *Uredinella spinulosa* Couch & Petch

In *Trans. Brit. Myc. Soc.* XIX, 193 (1935), I described and figured, under the title 'A sterile stroma', a fungus found on *Aspidiotus* sp. on *Psychotria* at Nuwara Eliya, Ceylon. Subsequently, Dr J. N. Couch published a paper in *Mycologia*, XXIX, 665–73 (1937), entitled 'A new fungus intermediate between the rusts and *Septobasidium*', in which he instituted a new genus, *Uredinella*, with the species, *Uredinella coccidiophaga*. As the Ceylon fungus appeared to fall in this new genus, specimens were sent to Dr Couch who has described them as *Uredinella spinulosa* Couch & Petch in *Mycologia*, XXXIII, 405 (1941). Two collections were made from the same bush, on 28 August 1926 and 16 January 1927, respectively. The figure referred to above was drawn from a stroma of the first collection which was sterile, but Dr Couch found fertile stromata in the material sent him. He describes the cells figured by me as 'teleutospore-like cells'. The teleutospore is spherical or pyriform, with an apical germ pore, and produces a cylindrical four-celled basidium, 63–72 × 6·3–7·5 μ, with sterigmata about 7 μ long which bear bent-elliptic, hyaline, smooth basidiospores, 21–23 × 4·6–5·4 μ. There are also elongated-oval, teleutospore-like cells, with an apical germ pore, each of which produces an allantoid hyaline spore, 45–58 × 3·8–5 μ, directly. Similar allantoid spores were considered homologous with uredospores in the generic type species, *Uredinella coccidiophaga*.

200. *Laboulbeniales*

No one has yet systematically collected *Laboulbeniales* in this country, and the British list still consists chiefly of chance discoveries on museum specimens, any of which are welcome in the present state of our knowledge. Two more occurrences on fresh specimens have come to my notice, viz. *Laboulbenia vulgaris* Peyr. on *Bembidium assimile*, found by Mr J. C. F. Fryer at Woodwalton, 4–6 July 1931, and *Rhachomyces Philonthinus* Thaxter on *Philonthus varians* Payk., found by Mr H. Britten at Cotterill Clough, Cheshire, 16 November 1943. These are not 'new to Britain', both names being included in Bisby and Mason's *List of Pyrenomycetes recorded for Britain*. With regard to the latter list, the following may be noted.

The genus *Rhadinomyces* was merged by Thaxter in *Corethromyces*, and the British species, *Rh. pallidus* now stands as *Corethromyces pallidus* Thaxter, *Proc. Amer. Acad.* XLVIII, 180 (1912).

Bisby and Mason include *Monoicomyces Homalotae* Thaxter in the British list, but the evidence is somewhat confusing. In *Mon.* V, 43, Thaxter referred to 'The British types of this species from *Homalota putrescens*'. In *Mon.* II, 269, he wrote, 'the form occurring on *H. putrescens* in Britain'. But in *Mon.* II, 268, *M. Homalotae* was described from *H. putrescens*, B.M. No. 412, Azores. Unless there is further evidence, it would seem that the types are only British in the sense that they were found in the British Museum.

Under *Corethromyces Lathrobii*, Thaxter wrote, in *Mon.* II, 323, 'specimens corresponding in all respects to the type of this species were found in the Hope collection at Oxford on the European *L. quadratum*, labelled "Puyk. Gyll." [*sic*]. Whether this is a locality and if so where it is I am unable to say. The host is a European species.' Again, in *Mon.* V, 202, in connection with the same specimen he referred to 'the cryptic label "Payk. Gyll."' On mentioning this problem to Mr H. Britten, he informed me that the beetle was named by Paykull in 1789, and the addition of Gyll. presumably conveys the idea that the specimen is Gyllenhal's conception of Paykull's species. Mr Britten considers that we are justified in assuming that it was a British specimen.

(*Accepted for publication* 18 *January* 1944)

STUDIES ON BRITISH CHYTRIDS

II. A NEW CHYTRID ON *CERATIUM* AND *PERIDINIUM*

By C. T. INGOLD

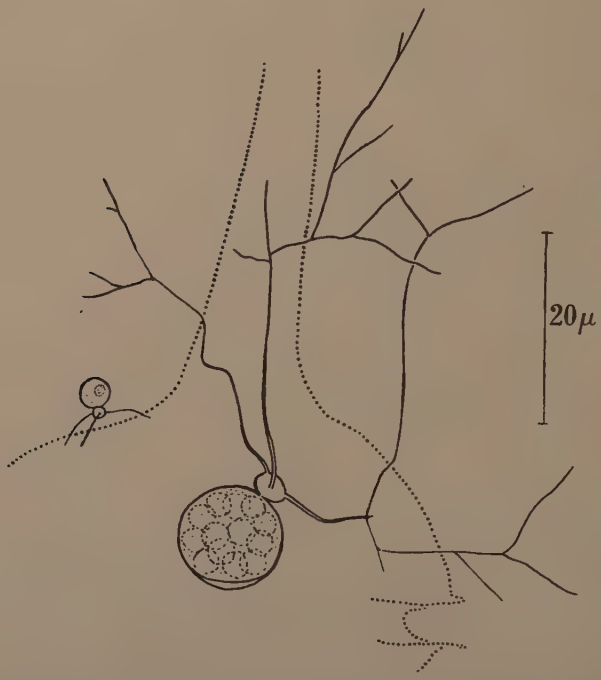
(With Plate IX and 3 Text-figures)

Apart from two species of *Rhizophydium* described by Dangeard (1888) as parasites of *Glenodinium cinctum*, chytrids have not been reported on members of the Dinophyceae. In July 1943, however, a chytrid was found in abundance on *Ceratium hirundinella* and, to a lesser extent, on a species of *Peridinium*, in a sample of plankton from Windermere. Unfortunately only material preserved in 4% formalin was available for study.

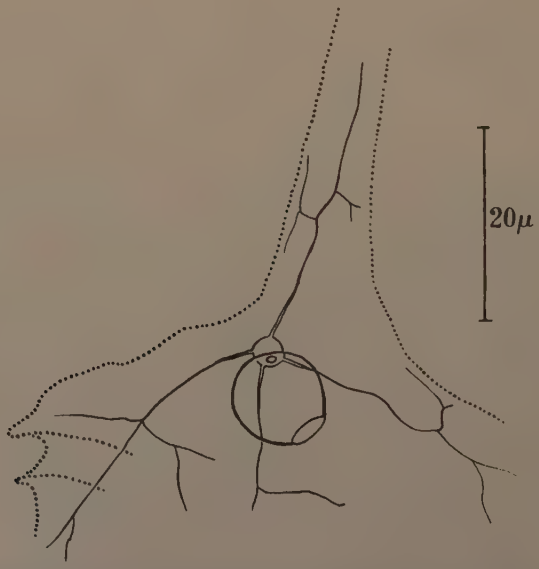
Ceratium hirundinella was abundant in this plankton and about half the individuals bore the chytrid. The contents of the infested cells appeared to be completely disorganized and, although the point could not be settled definitely from pickled material, it seemed that the fungus was saprophytic. The *Peridinium* was much less common in the plankton and only a few specimens were attacked.

The structure of the thallus is shown in Text-figs. 1–3 and in Pl. IX. It is monocentric, extramatrical and consists of a spherical sporangium (developed from the encysted zoospore) resting on a smaller spherical apophysis from which the three or four main axes of the rhizoidal system arise laterally. For a short distance these are unbranched and often act like the legs of a tripod raising the apophysis above the surface of the host cell. Distally the rhizoids taper and branch repeatedly on the surface of the *Ceratium* to produce an extensive rhizoidal system which seems to be entirely superficial, although some of the finer rhizoids may perhaps penetrate the wall of the host. Frequently, fine rhizoids trail out into the water and a heavily infected cell may have a regular fringe of these around it.

Text-figs. 1–3 illustrate examples in which only one or two chytrids were present on the host cell; these were chosen because it was easier to



Text-fig. 1. *Amphicypellus elegans*. A young individual and a mature one. The latter shows the lid and delimited zoospores. Part of the cell of *Ceratium* is shown by a dotted line: camera lucida drawing.

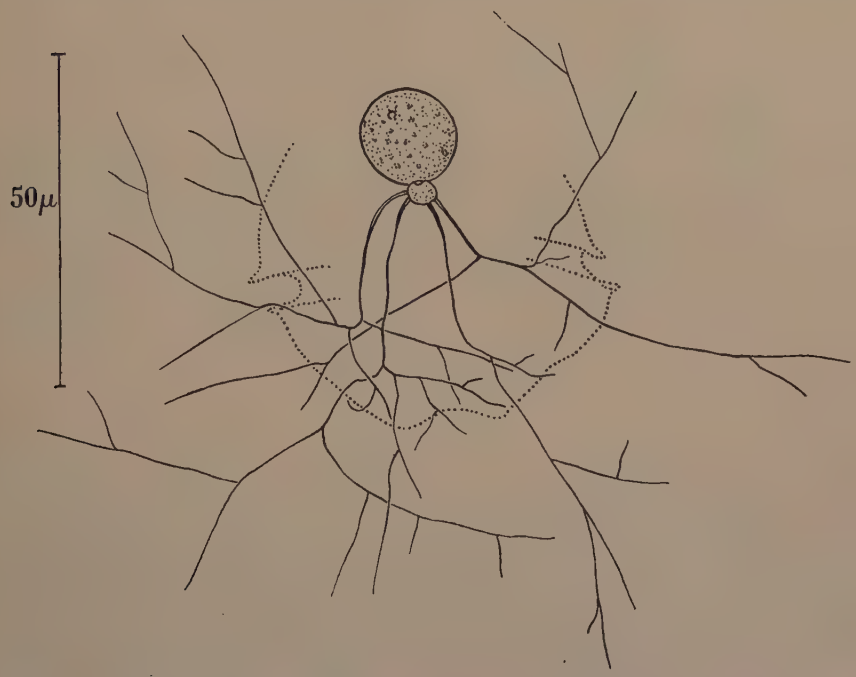


Text-fig. 2. *Amphicypellus elegans*. An old individual in which the sporangium has dehisced. Part of the apophysis and rhizoidal system are seen through the empty sporangium. Part of the cell of *Ceratium* is shown by a dotted line: camera lucida drawing.

trace the rhizoidal system. Usually, however, each host cell bore several chytrids, often as many as twenty occurred.

The apophysis is formed as a basal bud from the encysted zoospore, and, during thallus development, it always remains smaller than the sporangium. The isthmus between the two structures is extremely narrow so that it is difficult to see if there is a separating cross-wall.

The mature sporangium contains from ten to twenty spores. Dehiscence is subapical and the empty sporangium, which shows little tendency to



Text-fig. 3. *Amphicypellus elegans*. An exceptionally large specimen, not yet mature, growing on *Peridinium* sp. which is indicated by the dotted outline: camera lucida drawing.

collapse, has a relatively wide circular mouth. Undehisced sporangia, containing delimited spores, show a distinctly thickened part of the wall (Text-fig. 2) corresponding, in position, with the mouth of the dehisced sporangium. This suggests that the chytrid is operculate, but this cannot be settled until dehiscence has been observed in living material.

In his classification of Chytridiales, Sparrow (1943) lays stress on dehiscence of the sporangium, dividing the order into two series: Inoperculatae and Operculatae. If the sporangium is inoperculate, the fungus might be placed in the genus *Rhizoclosmatium*. If it is operculate, the fungus should go into the Chytridiaceae, but that family has no genus of monocentric, apophysate chytrids with an extramatrical rhizoidal system. The available evidence points to the chytrid being operculate, and it is proposed, therefore, to erect a new genus, *Amphicypellus*, represented by the

single species, *A. elegans*. The generic name is suggested by the resemblance of the sporangium with its apophysis to the double cup (δέπας ἀμφικύπελλον) of the Greeks.

Amphicypellus n.gen.

Thallus monocentric, eucarpic, extramatrical, consisting of an operculate sporangium and an apophysis with a rhizoidal system arising from it.

Amphicypellus gen.nov.

Thallus monocentrus, eucarpus, extramatricalis, constans e sporangio operculato et apophysi unde systema rhizoideum exoritur.

Amphicypellus elegans n.sp.

Thallus monocentric, extramatrical consisting of a sporangium, apophysis and rhizoidal system. Sporangium spherical, 8–16 μ in diameter, containing 10–30 spores, dehiscing by a subapical lid. Apophysis globose 3–5 μ in diameter. Rhizoidal system consisting of three or four main axes arising laterally from the apophysis; each main axis tapering and distally divided into numerous fine branches.

On dead cells of *Ceratium hirundinella* and *Peridinium* sp. from Windermere, England.

Amphicypellus elegans sp.nov.

Thallus monocentrus, extramatricalis, e sporangio, apophysi et systemate rhizoideo constans. Sporangium globosum, 8–16 μ diam., 10–30 sporis, dehiscens operculo sub-apicali. Apophysis globosa, 3–5 μ diam. Systema rhizoideum e 3 vel 4 principalibus axibus constans qui ex apophysi a lateribus exoriuntur; unusquisque principalis axis ad finem tenuatur et in plurimos ramulos dividitur.

Hab. in cellulis mortuis *Ceratii hirundinellae* et *Peridinii* sp. a Windermere, Anglia.

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Sparrow, F. K. (1943). *Aquatic Phycomycetes*. Ann Arbor.

EXPLANATION OF PLATE IX

Amphicypellus elegans n.gen., n.sp. on *Ceratium hirundinella* O.Fr.M.

Fig. 1. In the uppermost specimen the sporangium, apophysis and two of the three main rhizoids are visible. The first branching of one of these can be seen. A number of fine rhizoids project into the water around the host cell. ×722.

Fig. 2. At the top on the left is a nearly ripe specimen showing two of the three main rhizoids springing from the apophysis. Lower, on the right, is a very young specimen with its apophysis resting on the surface of the host cell. ×717.

Fig. 3. This specimen shows the three main rhizoids arising from the apophysis. ×666.

Fig. 4. The lateral origin of the main rhizoids from the apophysis is visible, but the main rhizoids themselves are somewhat out of focus. ×930.

(*Accepted for publication* 22 *January* 1944)

Fig. 1.

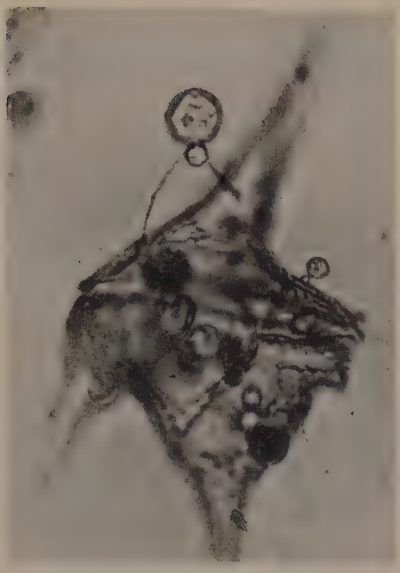

Fig. 2.

Fig. 3.

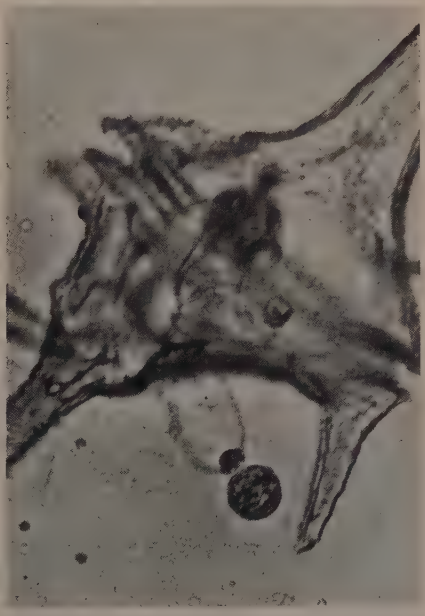

Fig. 4.

PLANT PATHOLOGY FIELD DAY, LONG ASHTON

25 June 1943

The Eighteenth Annual Plant Pathology Field Day was held at the Long Ashton Research Station, Bristol, by kind permission of the Director, Prof. B. T. B. Barker, M.A., on Friday, 25 June 1943.

About twenty visitors assembled at Long Ashton for a picnic lunch after which parties were made up to visit the exhibits and demonstrations prepared by the Station Staff. The subjects dealt with were:

Manurial deficiency symptoms in fruit and vegetables; Spraying techniques and appliances; Potato virus diseases; *Didymella* on tomato; New developments in fungicides; Bio-assays of fungicidal value; Mechanism of fungicidal action; Yeasts and cider making; and a new form of cider sickness. The exhibits were explained and discussed by the following: The Director, the Deputy Director (Dr T. Wallace), and Messrs Kearns, Marsh, Charley, Martin, Croxall, Hickman, Wilkinson, Wain and Campbell.

All the demonstrations were greatly appreciated and sincere thanks are due to the Director and Staff of the Long Ashton Research Station for the trouble they took to make the meeting both instructive and interesting. The weather played its part nobly and everyone agreed that the meeting was a great success.

J. H. Western
Secretary, Plant Pathology Committee

ANNUAL GENERAL MEETING

11 December 1943

The Annual General Meeting was held in the rooms of the Linnean Society of London on Saturday, 11 December 1943, with the President, Dr S. P. Wiltshire, in the Chair.

After the Minutes of the last Annual Meeting had been read and signed, the President announced with deep regret the deaths of five members: Mr A. W. Bartlett, Sir E. J. Butler, Dr Howard A. Kelly, Dr M. Mitra (who died in 1942), and Dr G. Morgan.

In the course of comments on the past year, the President reported that as a result of recommendations by the Joint Committee set up by the Society and the Association of Applied Biologists the Council of the Association had recently appointed a Plant Pests and Diseases Committee so that the Society's Plant Pathology Committee could now devote all its energies to mycological aspects of plant pathology. He also drew attention to the need for manuscripts intended for publication in the *Transactions* to be kept as brief as possible on account of the paper shortage and the great increase in printing costs. After he had expressed the Society's thanks to the Linnean Society for its hospitality, the year's accounts were submitted by Mr A. A. Pearson and adopted.

The following officers and councillors for 1944 were then elected: *President*, R. W. Marsh, M.A.; *Vice-Presidents*, G. Smith and the two past-presidents, S. P. Wiltshire and Miss E. M. Blackwell; *General Secretary*, J. Ramsbottom; *Secretary*, G. C. Ainsworth; *Treasurer*, A. A. Pearson; *Editors*, B. Barnes and H. Wormald; *Councillors*, Miss M. A. Brett, A. H. Campbell and Miss L. E. Hawker (to replace R. V. Harris, N. C. Preston and G. Smith). The Plant Pathology Committee's nominations of R. W. G. Dennis, K. St G. Cartwright and N. C. Preston (to replace W. J. Dowson, W. P. K. Findlay and R. W. Marsh) were agreed to. Five new members were elected, making twenty-one for the year.

After the General Secretary had indicated Council's tentative proposals for 1944 there was an adjournment until 2 o'clock when the President delivered his address entitled, 'The organization of the study of systematic mycology'. A vote of thanks to Dr Wiltshire concluded the meeting.

G. C. Ainsworth
Secretary

RECEIPTS AND PAYMENTS

for the Year ending 30 June 1943

		£	s.	d.			£	s.	d.
1942					1943				
1 July	Balance brought forward ...	773	10	4	20 March	Cambridge University Press: Cost of Vol. XXV *Transactions* and Reprints ...	771	5	2
1943						Cost of Reprint of Sampson & Western, *Diseases of British Grasses and Herbage Legumes*	76	13	7
20 March	Sale of *Transactions*:								
	Current Vol.	106	5	2	30 June	Postage, etc.			
	Back Vols.	70	17	0		Treasurer	3	0	3
	Sale of Reprints	25	7	0		General Secretary	4	17	8
						Secretary	10	15	4
30 June	Subscriptions to date ...	293	3	9		Sec. Path. Committee ...	2	5	0
	Gifts to Printing Fund ...	3	15	0		Editor	1	10	4
	Sale of					Sundry Printing	11	15	3
	British Basidiomycetae ...	5	9	3		Fees of Meetings	3	4	0
	Diseases of British Grasses...	42	14	8		Purchase of *Transactions* ...	1	5	0
	Deposit Interest	1	19	10		Binding 25 Vols. *Transactions*	9	7	6
	War Loan Interest	17	10	0		Honorarium to Miss Gooby...	4	4	0
						Purchase £200 Defence Bonds for Printing Fund	200	0	0
						Balance in bank	240	8	11
		£1340	12	0			£1340	12	0

CAPITAL ACCOUNT—*Robinson Bequest* £50, *Cheesman Fund* £150, *Printing Fund* £500 } *invested in* £255 3½ % *War Stock.* £245 3½ % *War Loan Reg.* £200 3 % *Defence Bonds.*

A. A. PEARSON, Hon. Treasurer

Examined and found correct, F. G. GOULD

12 July 1943

PROCEEDINGS

Meeting held in the University Department of Botany, Bristol, 26 June 1943.
The President, S. P. Wiltshire, M.A., D.Sc., in the Chair.

C. G. DOBBS and Miss M. P. ENGLISH. *Piptocephalis* sp. parasitic on non-mucorine hosts.
A. H. CAMPBELL, Miss D. M. DAVIES and Miss P. M. LEWIS. Fungal spoilage of rose hip products.
C. G. DOBBS. Exhibit of *Mucor plasmaticus* Van Tiegh.
C. T. INGOLD. The distribution of aquatic Hyphomycetes in Britain.
E. H. WILKINSON. Dry Eye Rot of apples caused by *Botrytis cinerea* Pers. ex Fr.
R. W. MARSH. Notes on the spread of *Armillaria mellea* in fruit plantations.

Joint Meeting of the British Mycological Society and the Association of Applied Biologists, held in the Metallurgical Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, 23 October 1943.

In the morning the Chair was taken by Prof. W. Brown, F.R.S., President of the Association of Applied Biologists; in the afternoon, by the President of the Society, S. P. Wiltshire, M.A., D.Sc.

The programme, which had been arranged by the Plant Pathology Committee, comprised a series of papers on Vegetable Diseases. [For a detailed account of this meeting see *Ann. appl. Biol.* XXXI, 1944.]

FORAYS, 1943

In December 1942 Council appointed a Foray Committee consisting of W. Buddin, C. G. C. Chesters, C. T. Ingold, Mrs E. W. Mason, Miss E. M. Wakefield and the Secretary *ex officio*, to organize the Society's field work, and it was decided that, as it would again be impossible to hold a regular Autumn Foray, an effort should be made to collaborate with Natural History Societies in arranging a programme of day forays for 1943. The Hertfordshire Natural History Society and Field Club (4 Sept.), the Norfolk and Norwich Naturalists' Society (18, 19, 25 Sept., 21 Oct.), the Edinburgh Natural History Society (25 Sept.), the Yorkshire Naturalists' Union (1–4 Oct.), the Bournemouth Natural Science Society (5, 28 Oct.), the Reading and District Natural History Society (9 Oct.), and the Lincoln Naturalists' Union (16 Oct.) very kindly invited members to attend their forays, a joint foray with the South London Botanical Institute was held at Oxshott (25 Sept.), and the Society arranged forays in the London area to Englefield Green (8 Oct.), Ruislip (10 Oct.), and Epping Forest (16 Oct.).

A dry August had a deleterious effect on the numbers of fungi found at the Hertfordshire Natural History Society's foray to Bricket Wood, and lack of rain had a similar effect on the Edinburgh foray later in the month. Drought, however, did not affect the Norfolk and Norwich Naturalists' visit to Wheatfen Broad on 18 and 19 Sept., under the enthusiastic guidance of Mr E. A. Ellis, when, after complex amphibious operations, a number of very interesting fungi were recorded. Among them were *Omphalia Belliae* Johnst. on *Phragmites*, *Isaria tenuipes* Peck (which was plentiful at its only known British station), and other entomogenous fungi including *Melanospora parasitica* Tul., while Mr H. J. Howard added a number of Myxomycetes from the adjacent woods (for a longer list see *Trans. Norf. and Norwich Nat. Soc.* xv, 1944, 428).

The week-end foray arranged by the Mycological Committee of the Yorkshire Naturalists' Union to Burnsall-in-Wharfedale was the most ambitious of the season. Under the able leadership of the Y. N. U. Foray Secretary, Miss Grainger, and other stalwarts of this veteran Society, rich localities such as the Grassington Woods, Bolton Abbey Woods and other woods along the Wharfe were visited. Though no new records were made, the collections included *Clavaria amethystina* Fr., *Clitocybe concava* (Fr.) Gill.—both far from common—and the pyrenomycete *Cryptosphaerella annexa* (Nits.) Höhn., and much good work was done in the field and at the bench.

Fine weather and the hospitality of Dr Somerville Hastings made the Reading Natural History Society's foray in the Peppard area most enjoyable; in the morning a party made a round trip through the beech woods, and in the afternoon Kingwood Common was visited. During the day more than one good collection of edible fungi for the pot was made.

The Society's three forays to Englefield Green, Ruislip and Epping were well attended by both members and students, and on each occasion there was opportunity for the party to display and examine the collections. At Englefield Green, where the Society was once more indebted to Miss Blackwell of the Royal Holloway College for her hospitality, the Clockcase plantation again yielded much of interest, including *Cortinarius malachius* Fr. in quantity (see *Trans. Brit. Mycol. Soc.* xxvi, 43). Two days later the Ruislip woods proved particularly rich, and as a result of less than three hours' collecting specimens of over ninety species were named and exhibited; a further number taken home for examination bringing the total for the day to over 100. A noticeable feature of the forays in the Thames Valley was the abundance of *Amanita mappa* and *Lactarius vietus*.

UNA C. MASON
Secretary of the Foray Committee

REVIEW

The Boletaceae of North Carolina. By W. C. Coker and A. Holland Beers. University of North Carolina Press, Chapel Hill, North Carolina. Pp. viii and 96, 66 plates (6 coloured) and 1 text-figure. Price $7.00. Published 26 June 1943.

As compared with the amount of critical work on Agaricaceae which has been published in recent years, there is very little for students of the Boletaceae, and few good illustrations. Murrill, and more recently Snell, in the United States, have written critically on various species and genera, and have supplied keys. In Europe the detailed monograph begun by Kallenbach promised to fill the gap, but publication was slow and is probably now indefinitely postponed. The appearance of any comprehensive work on the group is therefore to be welcomed, and the present book, though dealing only with species found in North Carolina, is useful also to European students in that it draws attention to certain problems in the identification of old species, as well as to the distribution of species in Europe and North America.

On glancing through the work the first point that strikes one is the high proportion of endemic species. Of seventy-three species enumerated, only sixteen bear names which are also known in Europe, and one of these is represented only by a variety (*Boletus Satanas* var. *americanus*). One would like to know whether the differences are due to climate, or to the more abundant and more diversified vegetation of the New World, or whether there may not be species which are really the same in both regions but have been given different names. A suspicion that the latter may sometimes be true creeps in in connexion with the authors' treatment of the species of the *B. chrysenteron* group. They have adopted an old and vague name of Bulliard's, *B. communis* Bull., for a species which they keep distinct from both *B. subtomentosus* and *C. chrysenteron*. The description given by them of '*B. communis*' suggests *B. chrysenteron* as understood in Europe, but they cite Sow. *Engl. Fungi*, tab. 225, a figure of a bright red species which is here usually called *B. versicolor* Rost. It is possible that *B. bicolor* Peck, also listed, belongs to the same species.

In their citation of this pre-Friesian name, *Boletus communis* Bull., and of other names the authors entirely disregard the International Rules of Nomenclature, a proceeding which does not help to clarify matters. The provision of detailed descriptions taken from their own material, together with figures (coloured drawings and photographs), and much-magnified drawings of spores should however enable mycologists of America to identify the species growing in this region, and it may be possible later for a monographer of the European forms to sort out the relationship between species recorded on the two sides of the Atlantic.

After a short introduction, there are ten pages of keys to the species. The rest of the text consists of descriptions of the various species. The authors recognise the genus *Boletinus*, but not any of the other small genera which have been segregated from *Boletus* by modern workers.

As with other publications of the University of North Carolina Press the book is well produced, with clear typography and good figures. The price is high, but not excessive for these days.

E. M. Wakefield